# MONTANA SUN RIGHTS -
# A SOLAR EASEMENT MODEL
# FOR RURAL SUBDIVISIONS

*Prepared for*
*MONTANA DEPAPTMENT of NATURAL RESOURCES and CONSERVATION*

# MONTANA SUN RIGHTS - A SOLAR EASEMENT MODEL FOR RURAL SUBDIVISIONS

Prepared by

Thomas Stewart
8945 Douglas Circle
Helena, MT 59601

Eileen Shore
1202 North Lamborn
Helena, MT 59601

May, 1980

Prepared for

Montana Department of Natural Resources and Conservation
32 South Ewing, Helena, Montana 59620
Renewable Energy and Conservation Program
Grant Agreement Number 086-772

TABLE OF CONTENTS

# APPENDIX

A. EXAMPLE SUBDIVISION PLAT

B. EXAMPLE SOLAR EASEMENT OVERLAY

C. CONTOUR MAP OF EXAMPLE SUBDIVISION

D. GENERAL VICINITY MAP OF PROPOSED SUBDIVISION

E. AUTHORS' BACKGROUND

F. BIBLIOGRAPHY

# CHAPTER 1

## INTRODUCTION

The following paper presents a study which considers the problem of defining and establishing a solar easement over a residential subdivision area. The study is concerned with conditions found primarily in Montana for either existing or proposed rural residential subdivisions having lots approximately 1/2 acre or larger in size. Most rural subdivision areas in Montana originally have few trees, and in many cases are completely void of trees. These conditions provide an excellent opportunity to develop solar easements over these areas which will guarantee forever the landowner's unobstructed access to the sun's direct energy.

The study develops an easement description to protect a specific portion of land from any obstruction to sunlight. It is designed to protect land rather than a solar device to collect heat for a home.

The method proposed in this study was developed keeping the changing technology in mind. Home builders, for example, may not use active solar collector systems, but rather they may build semi-earth homes, using passive solar energy techniques. Many will be interested in developing large productive

gardens. In any case it is assumed that people will want to have and use in all cases the maximum available sun energy possible, and at the same time be willing to agree to share the air space over their lands.

The following study is an attempt to develop a draft model sun easement procedure. It should be of interest not not only to the general public, but in particular to govern--mental land use planning groups, land developers, lawmakers, engineers, and architects interested in solar energy.

One important conclusion of this report is that a recently enacted law, Chapter 524, Session Laws, 1979, is not suitable for the kind of easement contemplated by the technical portion of this study. That law is limited to protection of a particular solar collector. By contrast, this report develops a method, with a legal implementation procedure, which protects landowners' rights to unobstructed sunlight, or a defined part of their land, that they may make use of it in any way they wish in view of their own desires and developing technology.

In view of rapidly developing solar technology, the authors suggest that the approach adopted in this report is superior to any approach which limits solar access to protection of a particular solar device.

The study is broken into two parts; the legal consideration being primarily the work done by Eileen Shore, and the technical consideration done by Thomas Stewart, P.E.

The development and example use of the method is applied

to a proposed 40 acre subdivision currently being considered in an area three miles northwest of Helena, Montana.

# CHAPTER 2

# SOLAR EASEMENTS - TECHNICAL

## 2.1 Establishing the Critical Sun Angles

Table 1 shows the sun's altitude and azimuth angles measured from due south for 1,2,2 1/2,3,3 1/2, and 4 hours on either side of solar noon for the 21st of each month for the year. Table 1 is for a latitude of 46.58 degrees (Helena,Mt.).

The values were computed using the following relationships:

1. $D = 23.45[SIN(360(284 + N)]/365$

2. $SIN(A) = SIN(D)SIN(L) + COS(D)COS(L)COS(H)$

3. $SIN(Z) = COS(D)SIN(H)/COS(A)$

Where: D is the suns declination in degrees.
L is the latitude.
H is the hour angle from solar noon in degrees (15 degrees per hour).
N is the number of days from January 1.
A is the suns altitude.
Z is the suns azimuth measured from the south.

Note that the equations are independent of the longitude since the resulting altitudes and corresponding azimuth angles are computed with respect to solar noon. Also equation 1 is an emperical equation used to approximate the true declination of the sun. The resulting table values are not true angles, however, the error was found to be within +/- 1 degree for the daytime hours being considered. This error is negligible for the purpose of the analysis.

ALTITUDE AND AZIMUTH ANGLES FOR THE 21ST OF EACH MONTH
FOR HOURS FROM SOLAR NOON AT LATITUDE 46.58

| MONTH | | SOLAR NOON | 11:00AM 1:00PM | 10:00AM 2:00PM | 9:30AM 2:30PM | 9:00AM 3:00PM | 8:30AM 3:30PM | 8:00AM 4:00PM |
|---|---|---|---|---|---|---|---|---|
| JAN. | ALT | 23.3 | 21.9 | 18.0 | 15.2 | 11.9 | 8.2 | 4.2 |
| | AZI | 0.0 | 15.2 | 29.6 | 36.3 | 42.7 | 48.8 | 54.6 |
| FEB. | ALT | 32.2 | 30.7 | 26.3 | 23.2 | 19.6 | 15.6 | 11.3 |
| | AZI | 0.0 | 17.2 | 33.2 | 40.5 | 47.4 | 53.9 | 60.0 |
| MAR. | ALT | 43.0 | 41.2 | 36.2 | 32.7 | 28.7 | 24.4 | 19.8 |
| | AZI | 0.0 | 20.1 | 38.3 | 46.3 | 53.8 | 60.6 | 67.0 |
| APR. | ALT | 55.0 | 52.8 | 46.8 | 42.8 | 38.5 | 33.8 | 28.8 |
| | AZI | 0.0 | 24.8 | 45.7 | 54.4 | 62.2 | 69.2 | 75.6 |
| MAY | ALT | 63.6 | 60.9 | 54.0 | 49.6 | 44.9 | 40.0 | 34.9 |
| | AZI | 0.0 | 29.9 | 53.0 | 62.0 | 69.7 | 76.5 | 82.7 |
| JUNE | ALT | 66.9 | 63.9 | 56.6 | 52.1 | 47.3 | 42.3 | 37.2 |
| | AZI | 0.0 | 32.7 | 56.5 | 65.4 | 73.1 | 79.7 | 85.7 |
| JULY | ALT | 63.9 | 61.1 | 54.2 | 49.9 | 45.2 | 40.2 | 35.1 |
| | AZI | 0.0 | 30.2 | 53.3 | 62.3 | 70.0 | 76.8 | 83.0 |
| AUG. | ALT | 55.2 | 52.9 | 46.9 | 43.0 | 38.6 | 33.9 | 29.0 |
| | AZI | 0.0 | 24.9 | 45.8 | 54.6 | 62.3 | 69.3 | 75.7 |
| SEPT | ALT | 43.2 | 41.4 | 36.3 | 32.9 | 28.9 | 24.6 | 19.9 |
| | AZI | 0.0 | 20.2 | 38.4 | 46.5 | 53.9 | 60.7 | 67.1 |
| OCT. | ALT | 31.7 | 30.1 | 25.8 | 22.7 | 19.1 | 15.2 | 10.9 |
| | AZI | 0.0 | 17.0 | 32.9 | 40.2 | 47.1 | 53.6 | 59.7 |
| NOV. | ALT | 23.0 | 21.6 | 17.7 | 14.9 | 11.6 | 8.0 | 3.9 |
| | AZI | 0.0 | 15.1 | 29.5 | 36.2 | 42.6 | 48.6 | 54.4 |
| DEC. | ALT | 20.0 | 18.7 | 14.9 | 12.2 | 9.0 | 5.4 | 1.5 |
| | AZI | 0.0 | 14.5 | 23.3 | 34.8 | 41.1 | 47.0 | 52.6 |

TABLE 1

ALTITUDE AND AZIMUTH ANGLES FOR THE 21ST OF EACH MONTH
FOR HOURS FROM SOLAR NOON AT LATITUDE 49

| MONTH | | SOLAR NOON | 11:00AM 1:00PM | 10:00AM 2:00PM | 9:30AM 2:30PM | 9:00AM 3:00PM | 8:30AM 3:30PM | 8:00AM 4:00PM |
|---|---|---|---|---|---|---|---|---|
| JAN. | ALT | 20.9 | 19.6 | 15.9 | 13.2 | 10.1 | 6.6 | 2.8 |
| | AZI | 0.0 | 14.9 | 29.2 | 36.0 | 42.4 | 48.6 | 54.5 |
| FEB. | ALT | 29.8 | 28.3 | 24.2 | 21.3 | 17.9 | 14.2 | 10.1 |
| | AZI | 0.0 | 16.8 | 32.5 | 39.9 | 46.8 | 53.4 | 59.6 |
| MAR. | ALT | 40.6 | 38.9 | 34.3 | 31.0 | 27.3 | 23.2 | 18.8 |
| | AZI | 0.0 | 19.4 | 37.2 | 45.3 | 52.7 | 59.7 | 66.2 |
| APR. | ALT | 52.6 | 50.6 | 45.1 | 41.4 | 37.3 | 32.9 | 28.2 |
| | AZI | 0.0 | 23.5 | 43.9 | 52.7 | 60.6 | 67.7 | 74.3 |
| MAY | ALT | 61.1 | 58.7 | 52.5 | 48.5 | 44.1 | 39.4 | 34.6 |
| | AZI | 0.0 | 27.9 | 50.4 | 59.5 | 67.5 | 74.6 | 81.0 |
| JUNE | ALT | 64.4 | 61.8 | 55.2 | 51.1 | 46.5 | 41.8 | 37.0 |
| | AZI | 0.0 | 30.2 | 53.6 | 62.7 | 70.6 | 77.6 | 83.9 |
| JULY | ALT | 61.4 | 59.0 | 52.7 | 48.7 | 44.3 | 39.6 | 34.8 |
| | AZI | 0.0 | 28.1 | 50.7 | 59.8 | 67.8 | 74.8 | 81.3 |
| AUG. | ALT | 52.8 | 50.7 | 45.2 | 41.6 | 37.4 | 33.0 | 28.4 |
| | AZI | 0.0 | 23.6 | 44.0 | 52.8 | 60.7 | 67.9 | 74.5 |
| SEPT | ALT | 40.8 | 39.1 | 34.4 | 31.2 | 27.5 | 23.4 | 19.0 |
| | AZI | 0.0 | 19.5 | 37.3 | 45.4 | 52.8 | 59.8 | 66.3 |
| OCT. | ALT | 29.2 | 27.8 | 23.7 | 20.8 | 17.5 | 13.7 | 9.6 |
| | AZI | 0.0 | 16.6 | 32.3 | 39.6 | 46.5 | 53.1 | 59.3 |
| NOV. | ALT | 20.6 | 19.3 | 15.6 | 13.0 | 9.9 | 6.4 | 2.5 |
| | AZI | 0.0 | 14.9 | 29.1 | 35.8 | 42.3 | 48.4 | 54.3 |
| DEC. | ALT | 17.6 | 16.3 | 12.8 | 10.2 | 7.2 | 3.8 | 0.0 |
| | AZI | 0.0 | 14.3 | 28.1 | 34.6 | 40.8 | 46.8 | 52.6 |

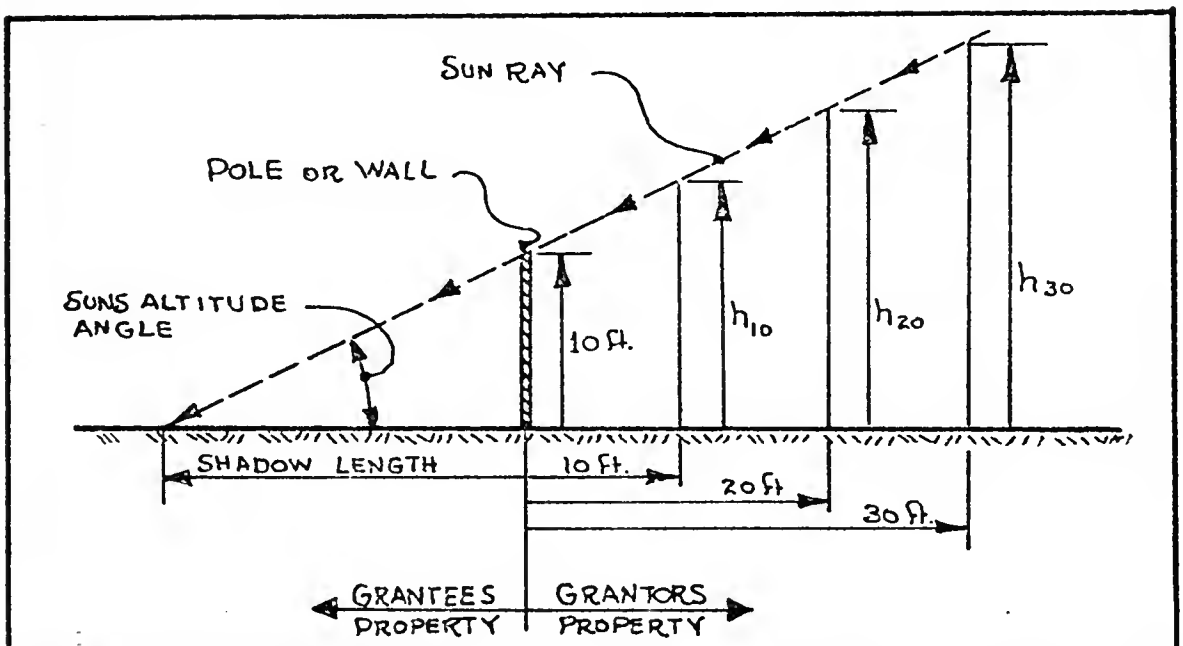
Table 2

ALTITUDE AND AZIMUTH ANGLES FOR THE 21ST OF EACH MONTH
FOR HOURS FROM SOLAR NOON AT LATITUDE 45

| MONTH | | SOLAR NOON | 11:00AM 1:00PM | 10:00AM 2:00PM | 9:30AM 2:30PM | 9:00AM 3:00PM | 8:30AM 3:30PM | 8:00AM 4:00PM |
|---|---|---|---|---|---|---|---|---|
| JAN. | ALT | 24.9 | 23.4 | 19.4 | 16.5 | 13.1 | 9.2 | 5.1 |
| | AZI | 0.0 | 15.4 | 29.8 | 36.6 | 43.0 | 49.0 | 54.7 |
| FEB. | ALT | 33.8 | 32.2 | 27.6 | 24.4 | 20.7 | 16.5 | 12.1 |
| | AZI | 0.0 | 17.5 | 33.6 | 41.0 | 47.8 | 54.2 | 60.3 |
| MAR. | ALT | 44.6 | 42.7 | 37.4 | 33.8 | 29.7 | 25.2 | 20.4 |
| | AZI | 0.0 | 20.6 | 39.0 | 47.1 | 54.5 | 61.2 | 67.5 |
| APR. | ALT | 56.6 | 54.2 | 47.9 | 43.7 | 39.2 | 34.3 | 29.2 |
| | AZI | 0.0 | 25.7 | 46.9 | 55.6 | 63.3 | 70.2 | 76.5 |
| MAY | ALT | 65.1 | 62.2 | 54.9 | 50.4 | 45.5 | 40.4 | 35.1 |
| | AZI | 0.0 | 31.4 | 54.8 | 63.6 | 71.2 | 77.8 | 83.8 |
| JUNE | ALT | 68.4 | 65.2 | 57.5 | 52.8 | 47.7 | 42.6 | 37.3 |
| | AZI | 0.0 | 34.5 | 58.6 | 67.3 | 74.7 | 81.1 | 86.9 |
| JULY | ALT | 65.4 | 62.5 | 55.2 | 50.6 | 45.7 | 40.6 | 35.3 |
| | AZI | 0.0 | 31.7 | 55.1 | 64.0 | 71.5 | 78.1 | 84.1 |
| AUG. | ALT | 56.8 | 54.4 | 48.0 | 43.9 | 39.3 | 34.4 | 29.4 |
| | AZI | 0.0 | 25.8 | 47.1 | 55.8 | 63.5 | 70.3 | 76.6 |
| SEPT | ALT | 44.8 | 42.9 | 37.6 | 34.0 | 29.8 | 25.3 | 20.6 |
| | AZI | 0.0 | 20.7 | 39.1 | 47.2 | 54.6 | 61.4 | 67.7 |
| OCT. | ALT | 33.2 | 31.6 | 27.1 | 23.9 | 20.2 | 16.1 | 11.7 |
| | AZI | 0.0 | 17.3 | 33.4 | 40.7 | 47.5 | 53.9 | 60.0 |
| NOV. | ALT | 24.6 | 23.1 | 19.1 | 16.2 | 12.8 | 9.0 | 4.8 |
| | AZI | 0.0 | 15.3 | 29.7 | 36.4 | 42.8 | 48.8 | 54.5 |
| DEC. | ALT | 21.6 | 20.2 | 16.3 | 13.5 | 10.2 | 6.5 | 2.5 |
| | AZI | 0.0 | 14.7 | 28.5 | 35.1 | 41.2 | 47.1 | 52.7 |

TABLE 3

Only the critical angles need to be used for the shadow analysis, and that is those angles that will cause the longest shadows to be cast for the entire year. A decision must be made as to the minimum altitude to use for early morning and late afternoon hours. Altitudes < than 10 degrees would obviously be impractical since this would cause very little space on a lot to be free from shadow and would simultaneously over-restrict the activities of the adjacent landowner. To limit altitudes to be > than 20 degrees would, on the other hand, cause a considerable waste of usable sun. This would be true especially for tracking collectors.




| SUNS ALTITUDE (Degrees) | SHADOW LENGTH (Feet) | $h_{10}$ (Feet) | $h_{20}$ (Feet) | $h_{30}$ (Feet) |
|---|---|---|---|---|
| 5 | 114.3 | 10.9 | 11.7 | 12.6 |
| 10 | 56.7 | 11.8 | 13.5 | 15.3 |
| 15 | 37.3 | 12.7 | 15.4 | 18.0 |
| 20 | 27.5 | 13.6 | 17.3 | 20.9 |

TABLE 4

Table 4 shows the shadow lengths cast onto the lot for a pole height of 10 feet for different altitude angles of the sun. h10, h20, and h30 values represent the allowable heights of objects that could occur on the land adjacent to the lot in question. For example, the adjacent land owner could have a fence or a planted wind break as high as 10 feet on the boundary and a house roof as high as 18 feet set back 30 feet from the boundary if the limiting altitude is 15 degrees for the sun. These objects would cast a 37 foot shadow onto the lot. If the limiting altitude angle were 5 degrees, a shadow length of 114 feet is cast. This not only greatly restricts the heights of objects on the adjoining land, but also would shadow too much of the lot. A square 1/2 acre lot size has about 150 foot sides, and, considering 10 foot shadow walls and a limiting altitude of 5 degrees, would leave little, if any, area free from shadow.

For subdivisions with lot sizes as small as 1/2 acre, it appears that limiting the altitude to near 15 degrees would be appropriate.

The circled entries in Table 1 for Helena's latitude were made using an altitude angle of 15 degrees as the criteria.

Note that the usable hours (in Table 1) are only two hours on each side of solar noon in December expanding to 2 1/2 hours for the months of November and January, then to 3 1/2 hours in October and February, then to 4 hours for the other months.

For comparison, Table 2 for latitude 49 degrees which is near Havre, Montana, show that only 1 hour on either side of solar noon is available in December, expanding to 2 hours in November and January, then to 3 hours in October, then to

3 1/2 hours in February and so on.

Table 3 is for a latitude of 45 degrees, which is near Bozeman, Montana. These sun angles are a little better than for Helena, but when the angles for the sun's altitude are rounded to the nearest 15 degrees, and the hours rounded to the nearest half hour, the resulting usable hours in the year are the same set as those for Helena.

It appears that the set of angles circled in Table 1 are the ones to use for the Helena area in the shadow analysis. The many tests made and presented in this study are based on this set of angles. The results indicate that this set of 17 positions should probably be adopted for the area. Table 5 summarizes these angles. Note that the minus azimuth angles are for hours before solar noon.

CRITICAL ANGLES USED FOR 46.58 DEGREES LATITUDE (HELENA MONTANA)

| NO. | AZIMUTH | ALTITUDE | TIME & MONTH |
|---|---|---|---|
| 1 | 0.00 | 20.00 | SOLAR NOON DEC 21 |
| 2 | 14.50 | 18.70 | 1:00 PM DEC 21 |
| 3 | -14.50 | 18.70 | 11:00 AM DEC 21 |
| 4 | 28.30 | 14.90 | 2:00 PM DEC 21 |
| 5 | -28.30 | 14.90 | 10:00 AM DEC 21 |
| 6 | 36.20 | 14.90 | 2:30 PM NOV OR JAN 21 |
| 7 | -36.20 | 14.90 | 9:30 AM NOV OR JAN 21 |
| 8 | 53.60 | 15.20 | 3:30 PM OCT OR FEB 21 |
| 9 | -53.60 | 15.20 | 8:30 AM OCT OR FEB 21 |
| 10 | 67.00 | 19.80 | 4:00 PM SEPT OR MAR 21 |
| 11 | -67.00 | 19.80 | 8:00 AM SEPT OR MAR 21 |
| 12 | 75.60 | 28.80 | 4:00 PM AUG OR APR 21 |
| 13 | -75.60 | 28.80 | 8:00 AM AUG OR APR 21 |
| 14 | 82.70 | 34.90 | 4:00 PM JULY OR MAY 21 |
| 15 | -82.70 | 34.90 | 8:00 AM JULY OR MAY 21 |
| 16 | 85.70 | 37.20 | 4:00 PM JUNE 21 |
| 17 | -85.70 | 37.20 | 8:00 AM JUNE 21 |

TABLE 5

## 2.2 Developing the Shadow Wall Algorithm

If one were to place a vertical 10 foot pole on level ground and compute the shadow cast for each of the 17 sun positions the results would be as shown in Fig 1-a. Any of the other infinite sun positions for the entire year with altitudes 15 degrees or larger would cast a shadow that would lie within the envelope line shown in the figure.

Figure 1-b shows the shadow envelope for the same pole and set of angles for ground that is tilted southward with a slope of 8 per cent.

Figure 1-c is an example of ground sloping westward at 8 per cent. Ground sloping eastward would be similar with the heavier lopsided shadow towards the east.

Figure 1-d is an example of ground tilted in a southwesterly direction. Figure 1-e is north, and Figure 1-f is tilted northwest.

Obviously south sloping ground is the least shadowed where north sloping ground would have the greatest amount of shadow for the year.

To develop an algorithm for a shadow analysis on a lot the vertical pole procedure discussed above was used to approximate an imaginary wall around the boundaries of the lot. This was done by dividing a lot side into 5 spaces giving 6 points. The shadow envelope is then computed for an imaginary pole placed at each of the 6 points. This is repeated for each side of the lot. The resulting pole shadows when plotted are enough to establish an overall shadow envelope for the entire lot.

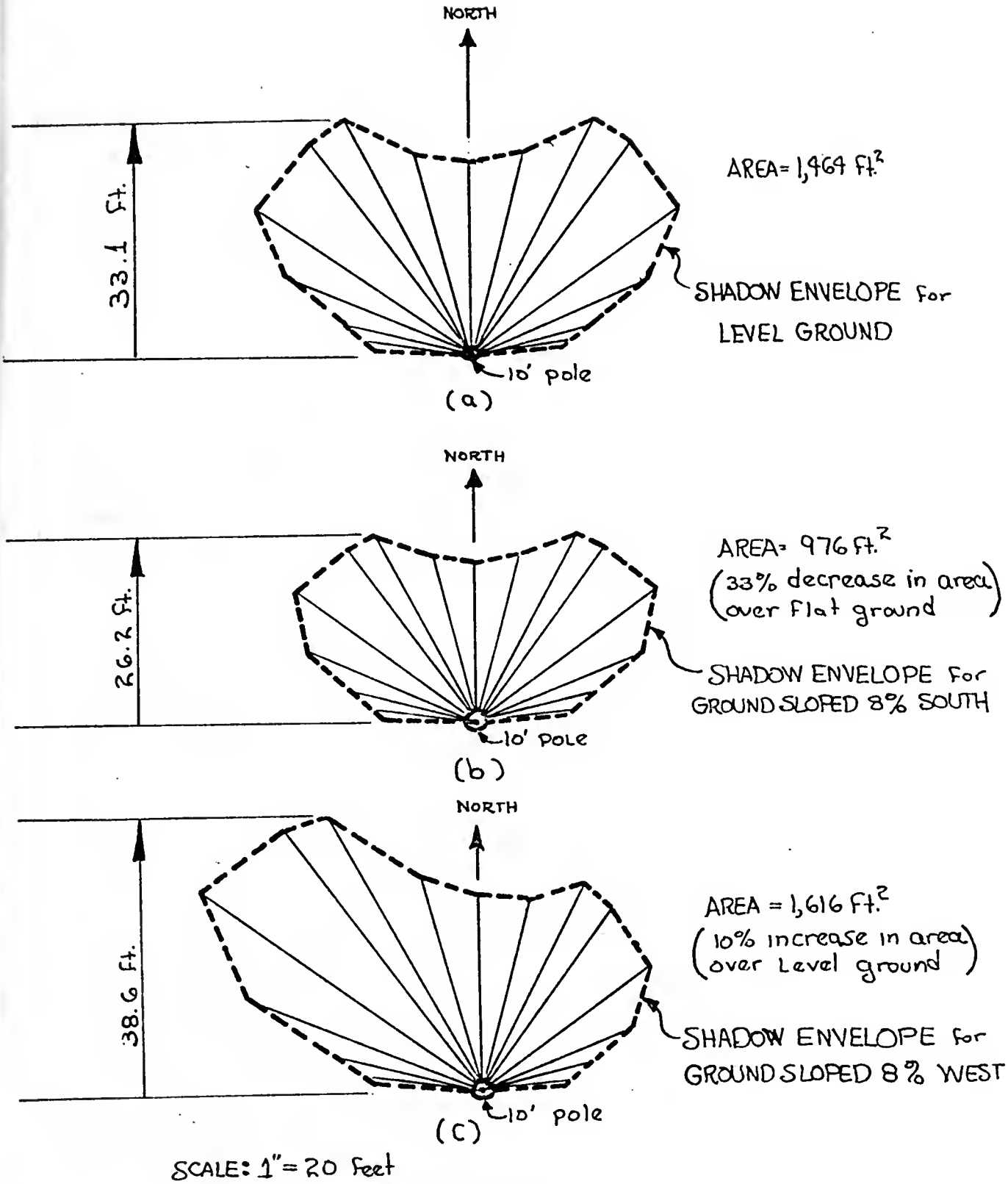

NORTH
33.1 ft.
AREA= 1,464 ft.²
SHADOW ENVELOPE for LEVEL GROUND
10' pole
(a)
NORTH
26.2 ft.
AREA= 976 ft.²
(33% decrease in area over Flat ground
SHADOW ENVELOPE for GROUND SLOPED 8% SOUTH
10' pole
(b)
NORTH
38.6 ft.
AREA = 1,616 ft.²
(10% increase in area over Level ground
SHADOW ENVELOPE for GROUND SLOPED 8% WEST
10' pole
(c)
SCALE: 1"= 20 Feet

FIGURE 1 - a,b,c

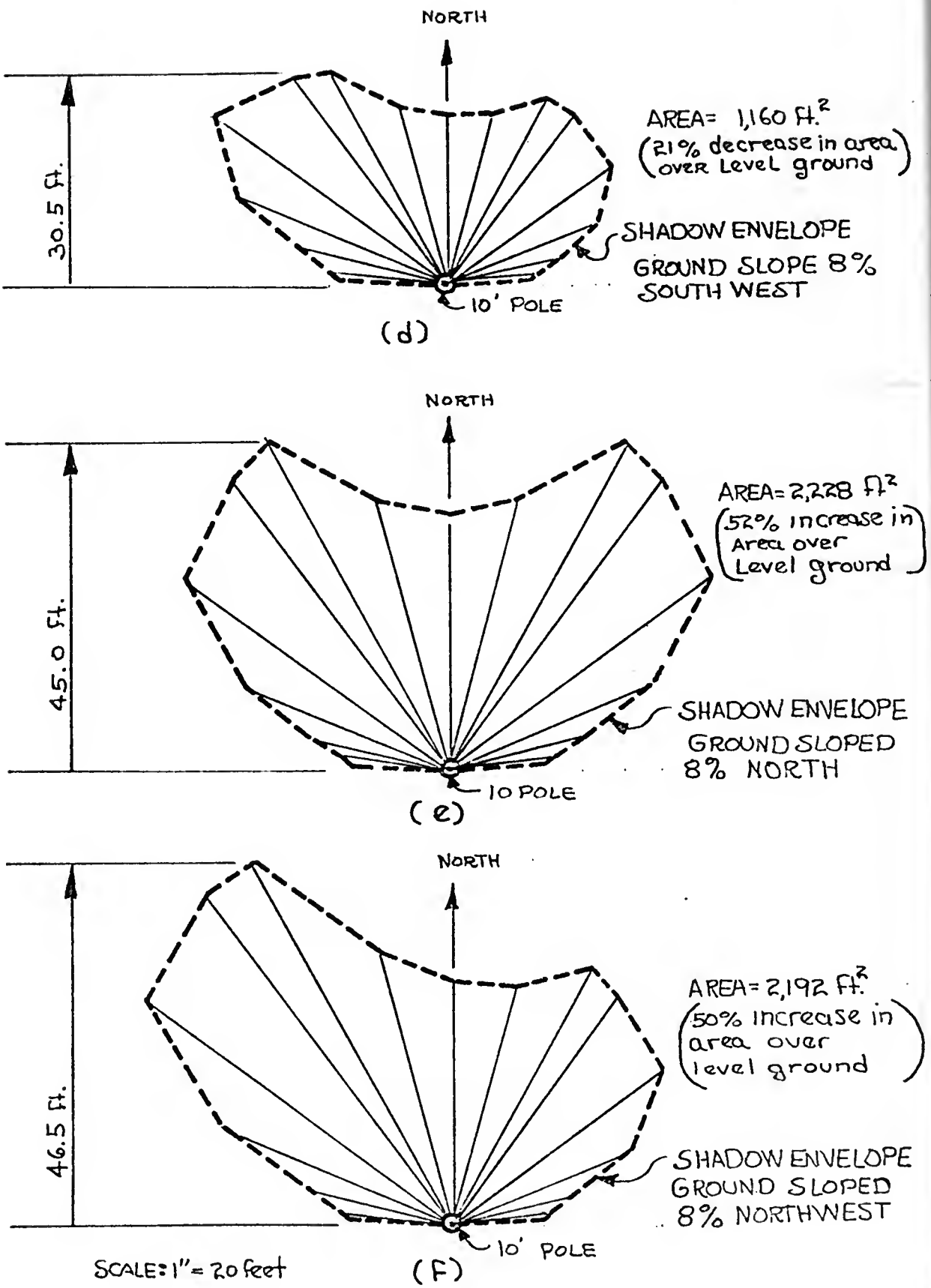

NORTH
30.5 ft.
AREA= 1,160 ft.²
(21% decrease in area over Level ground)
SHADOW ENVELOPE
GROUND SLOPE 8%
SOUTH WEST
10' POLE
(d)
NORTH
45.0 ft.
AREA= 2,228 ft²
(52% increase in Area over Level ground)
SHADOW ENVELOPE
GROUND SLOPED
8% NORTH
10 POLE
(e)
NORTH
46.5 ft.
AREA= 2,192 ft.²
(50% increase in area over level ground)
SHADOW ENVELOPE
GROUND SLOPED
8% NORTHWEST
10' POLE
SCALE: 1" = 20 feet
(F)

FIGURE 1 - d,e,f

The algorithm would be more useful if the shadow analysis accounted for the contour of the ground. A linear interpolation scheme offered an approximate solution for this problem, and was incorporated into the algorithm.

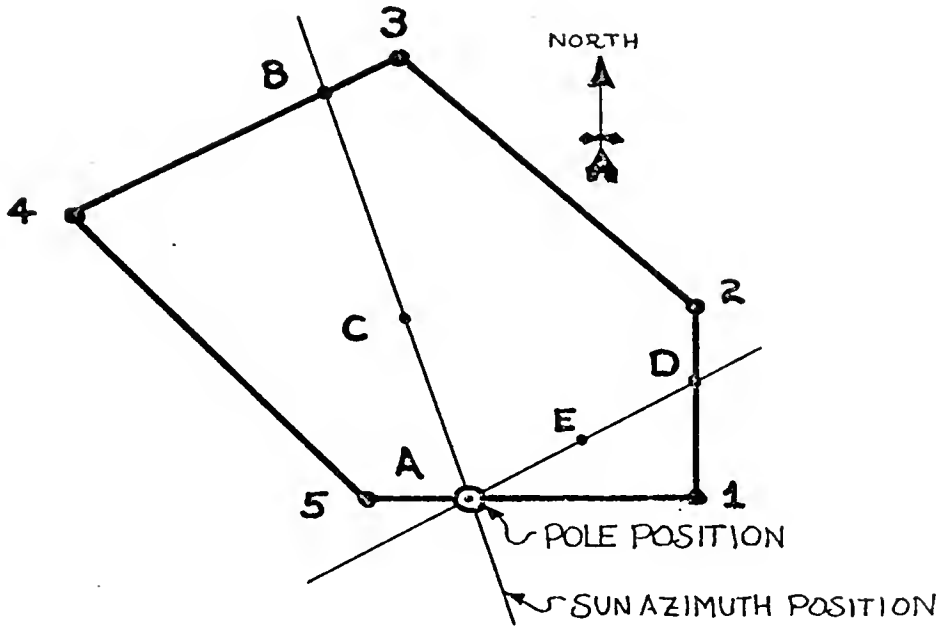



Figure 2

The scheme is explained as follows with reference made to Fig. 2. First the elevations of each lot corner are determined from a contour map of the area (Corners 1, 2, 3, 4, 5 in Fig 2. At a given pole position (A) on a lot side, the azimuth angle of a given sun position is treated as a line extended until it intersects at (B) with another lot side. The elevation at this point of intersection (B) is found by linear interpolation from the known elevations of lot side end points (3 and 4). The elevation at the pole point being analyzed is determined using interpolation between the points 1 and 5. The slope of the azimuth line (AB) is then determined. The sun

ray must intersect somewhere along this azimuth line. This point is then determined (Point C), and the horizontal distance from the pole position A to this point C of intersection is computed and becomes the shadow cast for the particular sun position. Line AD would be another sun position example where Point E is the intersection of the sun ray and the ground.

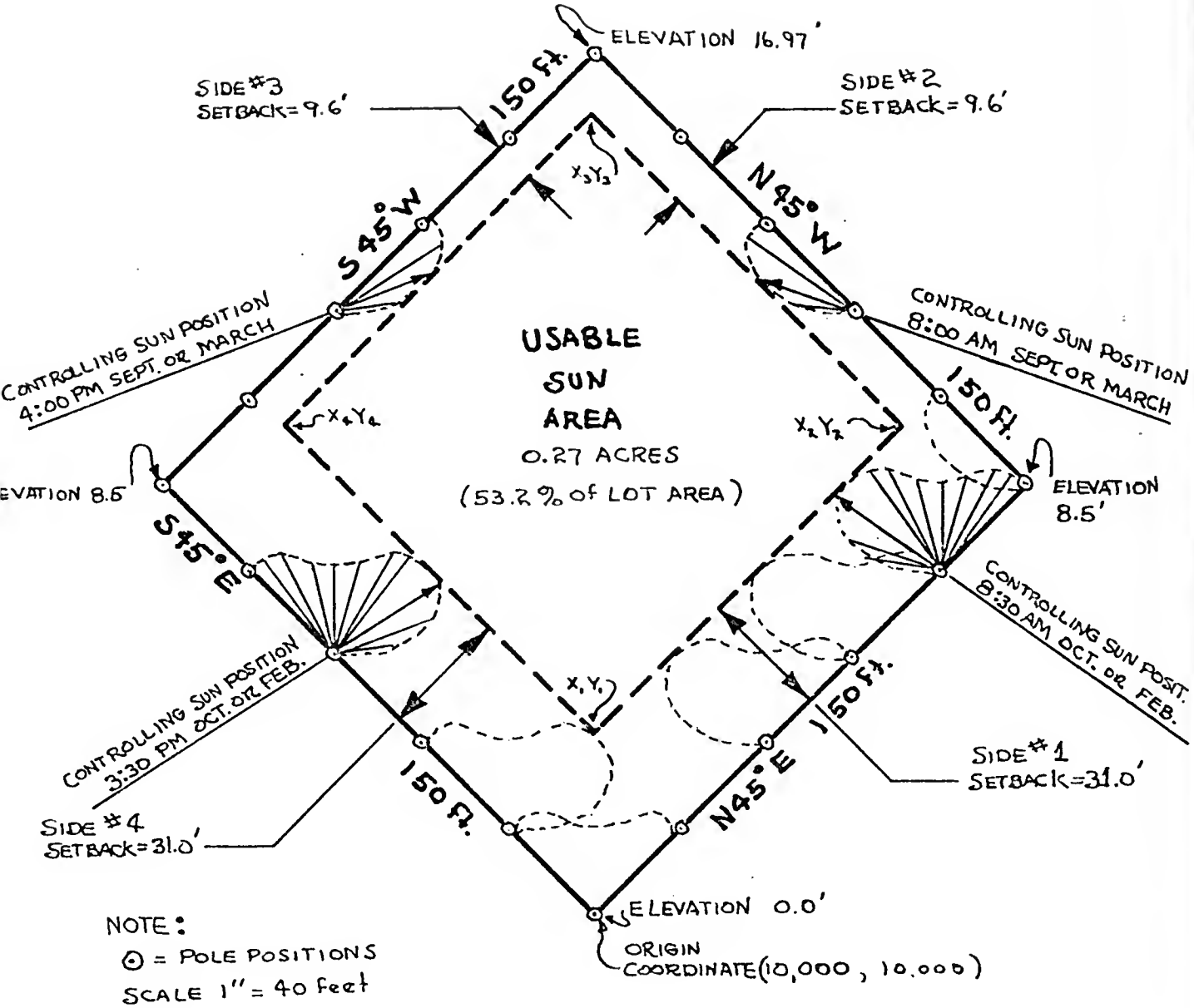
This is a satisfactory approximation method if the ground contour does not change abruptly in any direction. For relatively small lots of 1/2 acre to 1 acre this linear approximation should be reasonably accurate.

The computer is almost indispensible for applying this method. For a lot with five sides, for example, 25 different pole positions are analyzed; each for 17 sun positions or 425 shadow lines are computed for the lot. Also, the computer program allows many trial runs with simple changes in the parameters which are listed in detail as follows:

1. Lot Descriptions
    a. lot side lengths
    b. lot side bearings
    c. ground elevations
2. Shadow wall heights for each lot side
3. The set of 17 yearly critical sun angles (like those in Table 1)

Figure 3 is an example analysis on a lot applying the methods described above. The example uses a 150 ft. square lot oriented so the diagonal of the square lies due north.

Elevation values were computed for the lot corners so the plane of the lot slopes southward with an 8 per cent grade or slope. The computer output results are presented below the figure. The figure is well documented to demonstrate how the resulting computer analysis was carried out. The most southwest corner of the lot is arbitrarily given the coordinates 10,000, and 10,000 for computational purposes. Several of the pole shadows are plotted in detail. During the analysis the maximum perpendicular distance that occurs from the lot side to the shadow points is stored and printed in the output as the "setback" distance for the lot side. Out of the 17 sun positions used for each pole position the one that causes the maximum setback distance is printed as the controlling sun angle for the lot side. These are noted also in the figure.




**********

#20 TILTED SOUTH 8%

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10000.0 | 10043.8 | 31.0 | 8:30 AM OCT OR FEB 21 |
| 2 | 10 | 10077.4 | 10121.2 | 9.6 | 8:00 AM SEPT OR MAR 21 |
| 3 | 10 | 10000.0 | 10198.6 | 9.6 | 4:00 PM SEPT OR MAR 21 |
| 4 | 10 | 9922.6 | 10121.2 | 31.0 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 11976.9 SQ FT. ( 0.27 ACRES)
PERCENT USABLE IS 53.2 %

**********

FIGURE 3

Based on the shape of the lot and the ground elevations used for the lot corners, it would be possible to have a shadow line for a lot side which is not parallel to the lot side. Figure 4 demonstrates this condition.

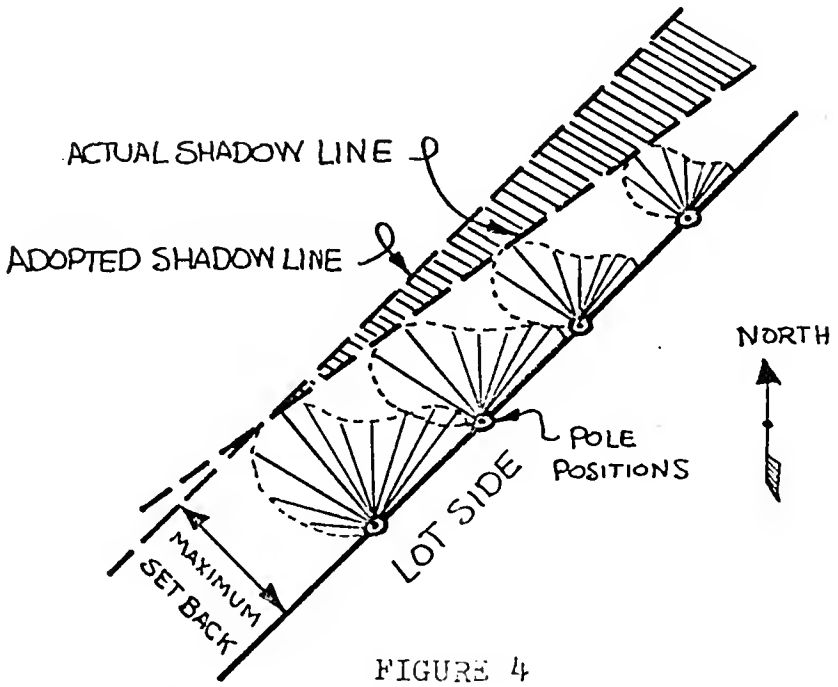



FIGURE 4

The intentions of the analysis, however, is to arrive at a way to describe in relatively simple terms the shadow lines for a lot so these descriptions can be incorporated into the legal statements which can be understood by the general public. It was decided, therefore, to use the maximum setback distance. With this value computed, the shadow line for the lot side is simply a line parallel to the surveyed lot side having a perpendicular distance from the lotside given by the setback values.

In some cases, depending on the ground contour, the shadow line would be conservative and the left over sun area

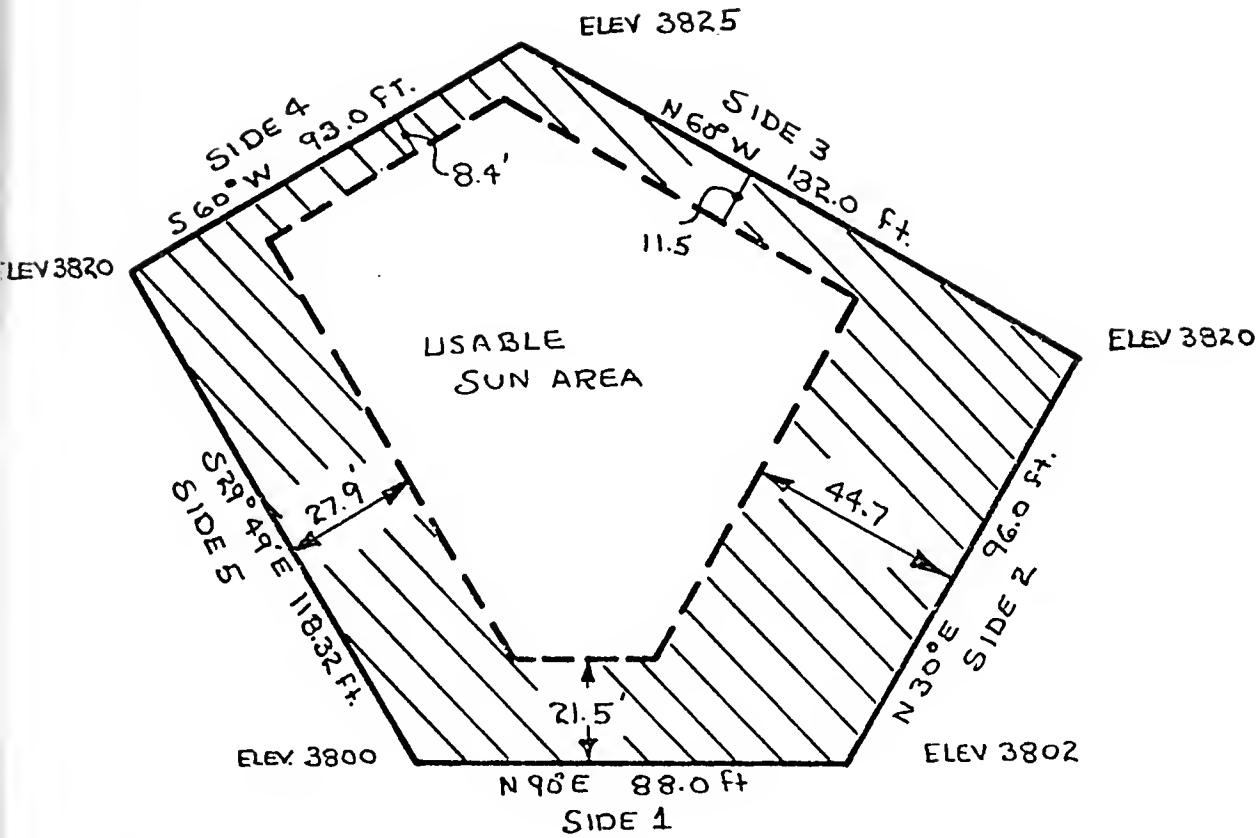
adopted for the lot may be slightly less than what might actually occur. This error is noted by the shaded portion in Figure 4.

## 2.3 Example Test Runs Using the Method

Figure 5 summarizes the results for an arbitrarily chosen five sided lot used to test the computer algorithm. The lot corner elevations were not computed to make the lot surface lie in a true plane, however, with the elevations used, the ground generally slopes southwest. Note that different shadow wall heights were used on lot sides.

In an actual application these wall heights would have to be carefully chosen depending on several considerations. Some of these considerations are as follows:

1. If the lot is a border lot adjacent to an industrial or commercial zoned area the shadow wall height would have to be relatively higher.
2. If a lot side is adjacent to a road then the wall height could be relatively lower.
3. If the lot sizes are relatively large then relatively larger wall heights can be chosen which would still leave a sizeable usable sun area and simultaneously cause less restrictions on activities in the adjacent land.




**********

TESTLOT NOTE: DIFFERENT WALL HEIGHTS

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10019.8 | 10021.5 | 21.5 | 10:00 AM DEC 21 |
| 2 | 15 | 10048.8 | 10021.5 | 44.7 | 8:30 AM OCT OR FEB 21 |
| 3 | 20 | 10091.5 | 10095.5 | 11.5 | 8:00 AM JUNE 21 |
| 4 | 15 | 10018.6 | 10137.7 | 8.4 | 4:00 PM JUNE 21 |
| 5 | 10 | 9969.5 | 10109.3 | 27.9 | 3:30 PM OCT OR FEB 21 |

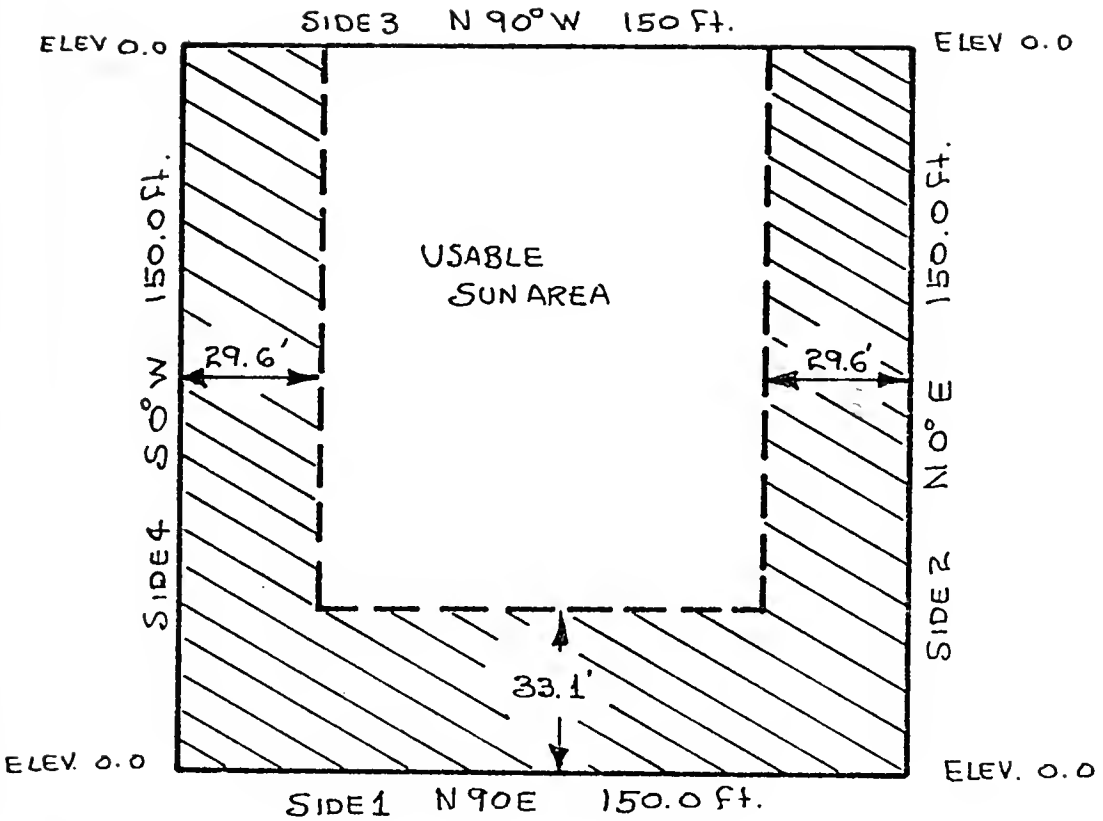
TOTAL AREA OF THE LOT IS 18402.3 SQ FT. ( 0.42 ACRES)
LEFT OVER SUN AREA IS 8147.1 SQ FT. ( 0.19 ACRES)
PERCENT USABLE IS 44.3 %

FIGURE 5

Figures 6, 7, 8, 9, 10, and 11 are results of computer runs made on 150 foot square lots that are approximately 1/2 acre in size. Figure 6 is a level lot. Figures 7, 8, 9, 10, and 11 have elevations to describe each lot as a true plane that has an 8 per cent slope in the south, west, southwest, north, and northwest directions respectively. Shadow wall heights were held constant at 10 feet.

Test runs presented in Figures 12, 13, 14, 15, 16, and 17 are identical in all respects to those in Figures 6 through 11 with exception to shape. In this case the area was held constant at 1/2 acre, but the eastwest lot side lengths were made 200 feet long and the northsouth sides 112.5 feet long.

Test runs presented in Figures 18 through 23 are for northsouth lot side lengths of 200 feet and eastwest lengths of 112.5 feet.




SCALE: 1" = 40 ft.

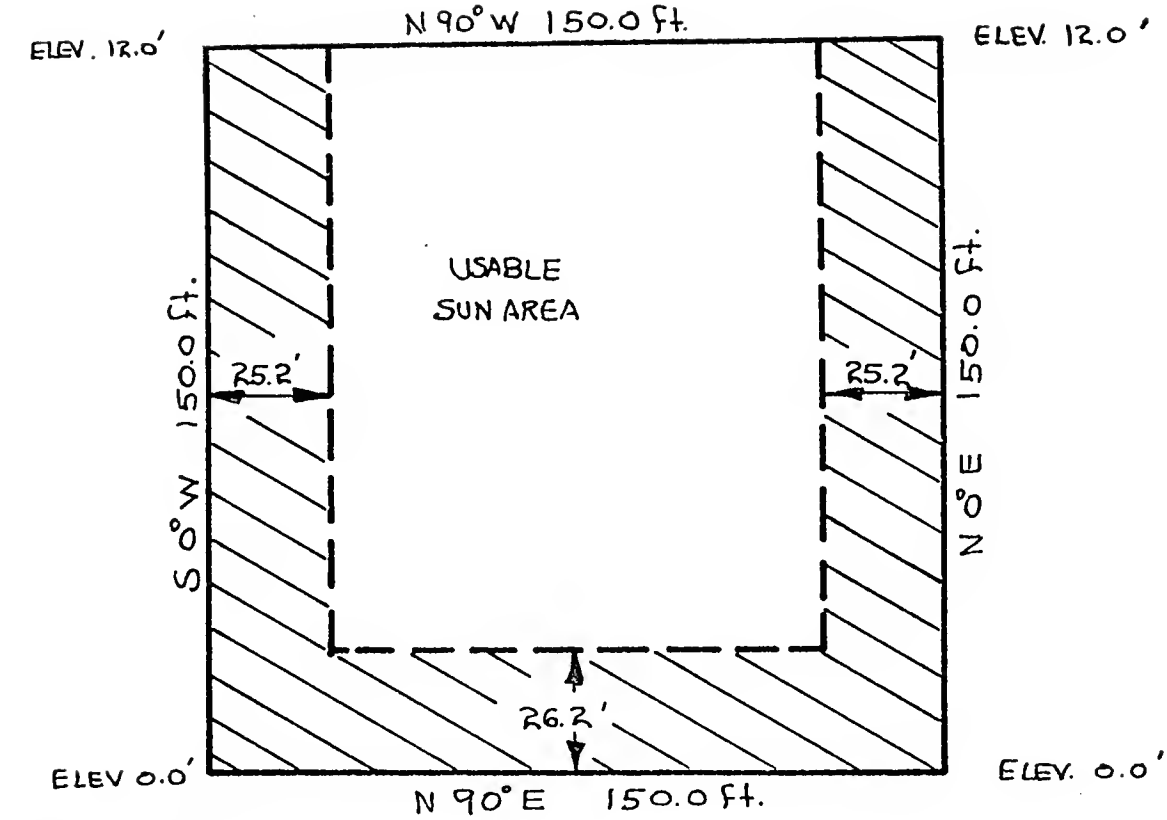
**********

#1 150 FT SQR LEVEL GROUND

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10029.6 | 10033.1 | 33.1 | 10:00 AM DEC 21 |
| 2 | 10 | 10120.4 | 10033.1 | 29.6 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10120.4 | 10150.0 | 0.0 | |
| 4 | 10 | 10029.6 | 10150.0 | 29.6 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 10609.5 SQ FT. ( 0.24 ACRES)
PERCENT USABLE IS 47.2 %

FIGURE 6




SCALE: 1" = 40 ft.

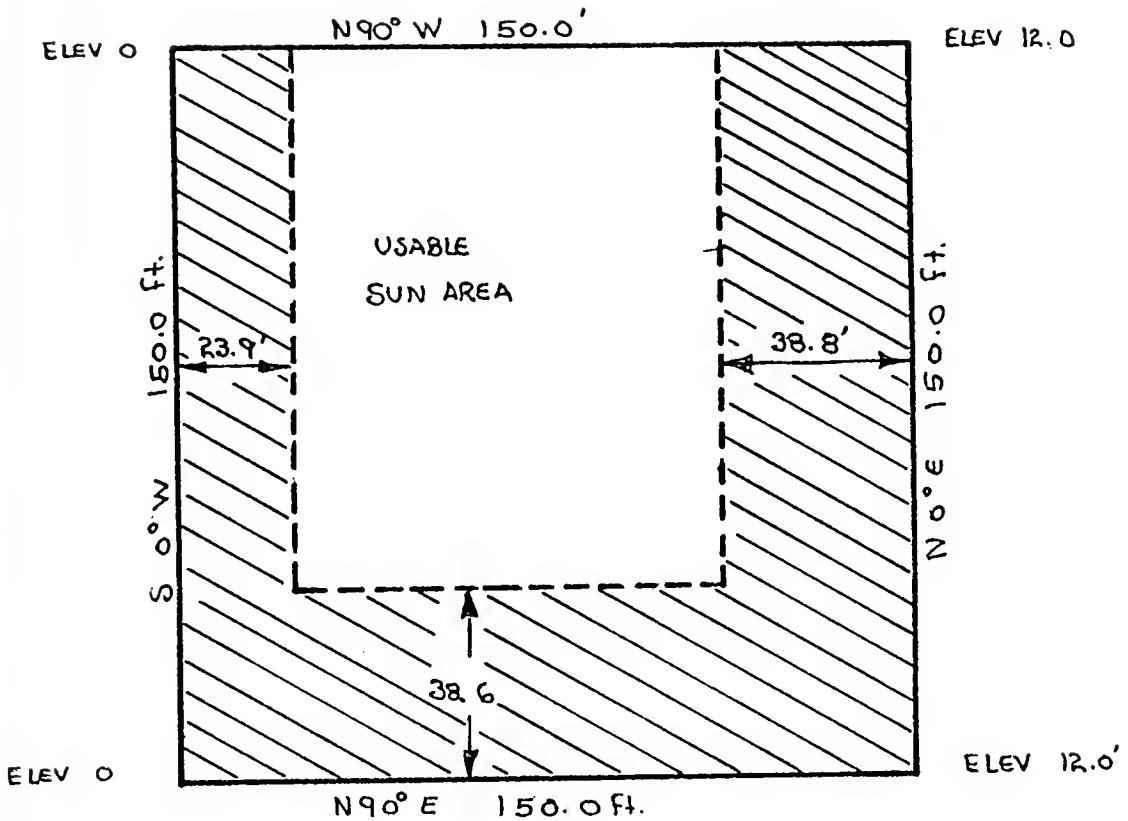
**********

#2 150 FT SQR SLOPE 8% SOUTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10025.2 | 10026.2 | 26.2 | 10:00 AM DEC 21 |
| 2 | 10 | 10124.8 | 10026.2 | 25.2 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10124.8 | 10150.0 | 0.0 | |
| 4 | 10 | 10025.2 | 10150.0 | 25.2 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 12329.4 SQ FT. ( 0.28 ACRES)
PERCENT USABLE IS 54.8 %

FIGURE 7




SCALE : 1"=40'.0

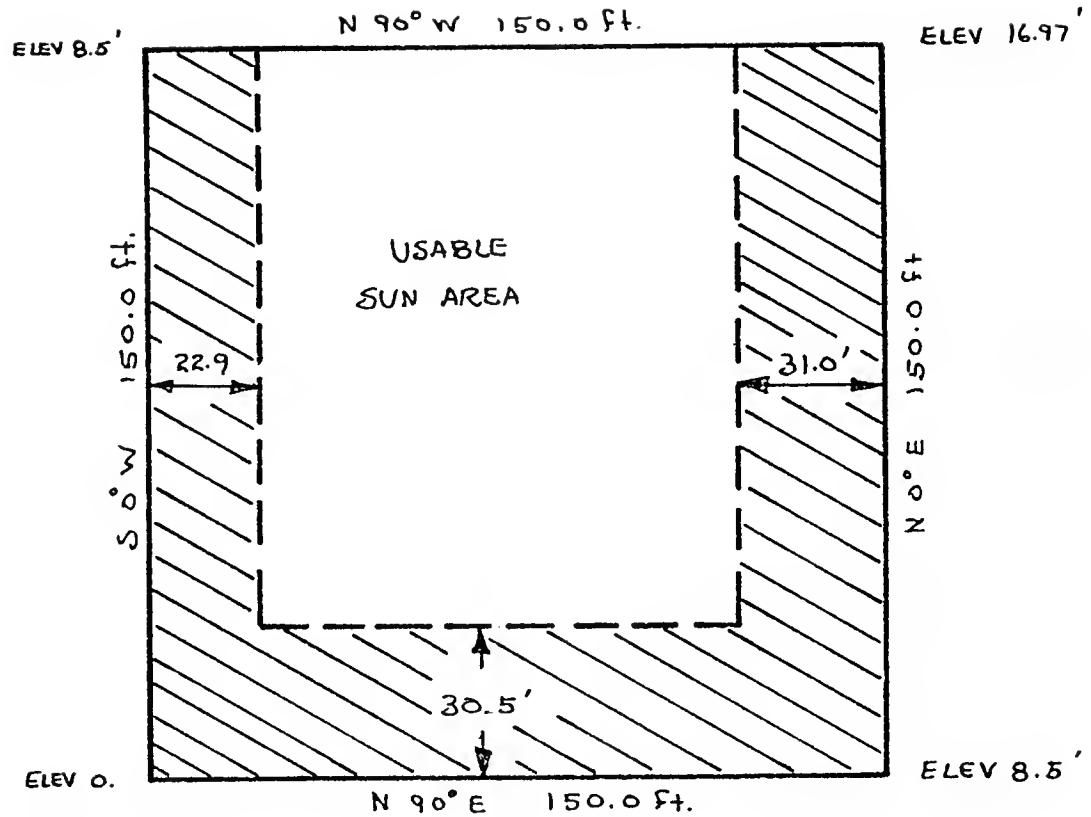
**********

#3 150 FT SQR SLOPE 8% WEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10023.9 | 10038.6 | 38.6 | 10:00 AM DEC 21 |
| 2 | 10 | 10111.2 | 10038.6 | 38.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10111.2 | 10150.0 | 0.0 | |
| 4 | 10 | 10023.9 | 10150.0 | 23.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 9717.5 SQ FT. ( 0.22 ACRES)
PERCENT USABLE IS 43.2 %

FIGURE 8




SCALE: 1"= 40'

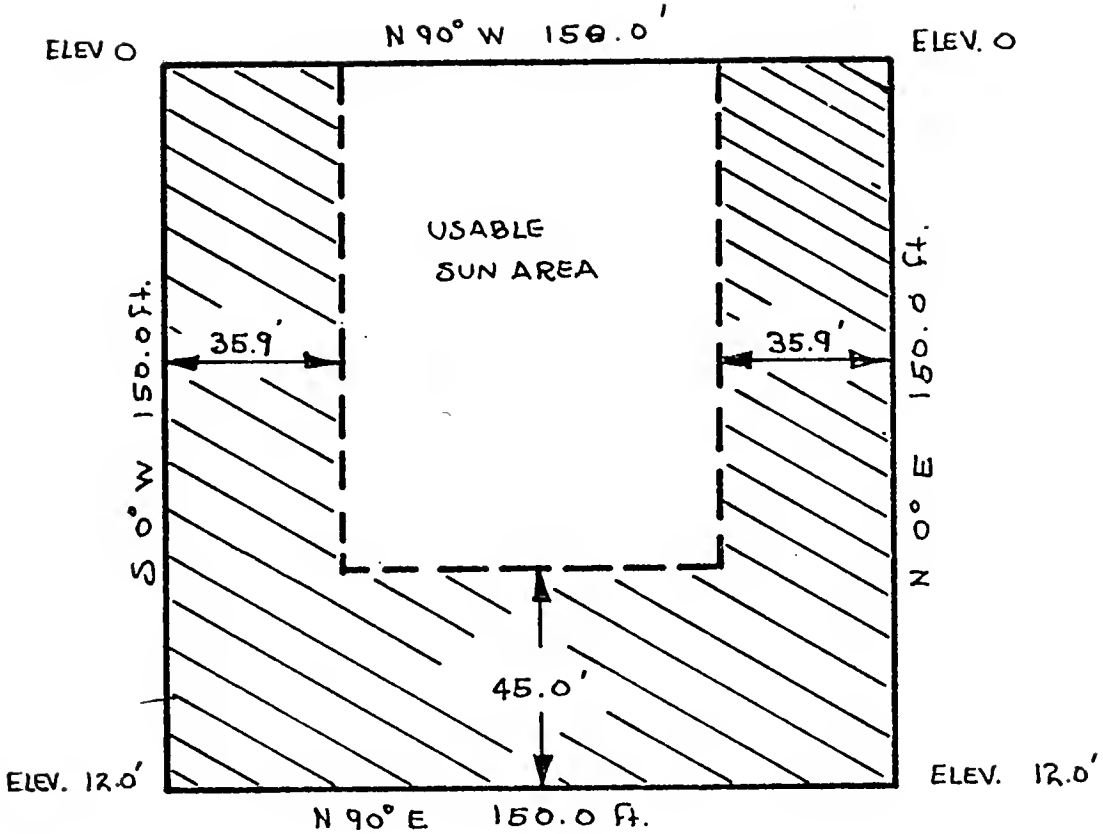
**********

#4 150 FT SQR SLOPE 8% SOUTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10022.9 | 10030.5 | 30.5 | 10:00 AM DEC 21 |
| 2 | 10 | 10119.0 | 10030.5 | 31.0 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10119.0 | 10150.0 | 0.0 | |
| 4 | 10 | 10022.9 | 10150.0 | 22.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 11483.2 SQ FT. ( 0.26 ACRES)
PERCENT USABLE IS 51.0 %

FIGURE 9




SCALE 1"= 40'

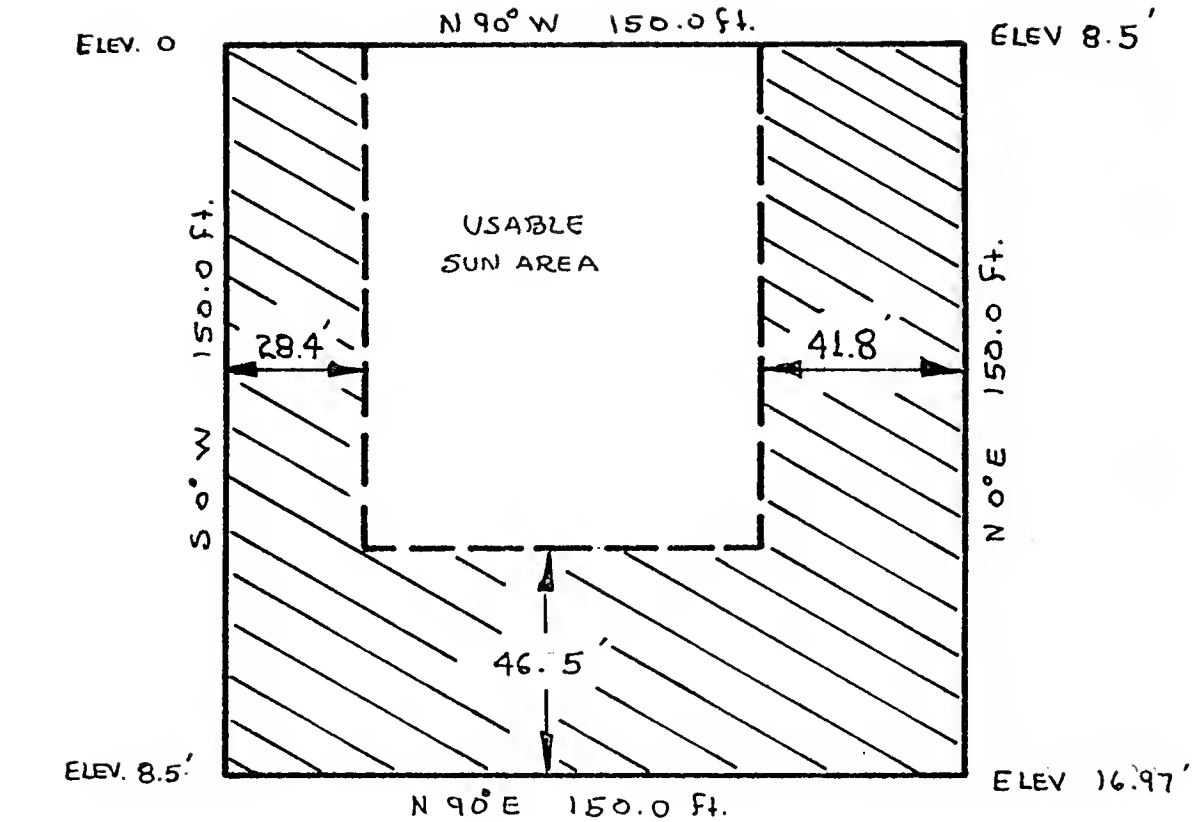
**********

#5 150 FT SQ SLOPE 8% NORTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10035.9 | 10045.0 | 45.0 | 10:00 AM DEC 21 |
| 2 | 10 | 10114.1 | 10045.0 | 35.9 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10114.1 | 10150.0 | 0.0 | |
| 4 | 10 | 10035.9 | 10150.0 | 35.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8211.2 SQ FT. ( 0.19 ACRES)
PERCENT USABLE IS 36.5 %

FIGURE 10




SCALE 1"= 40'

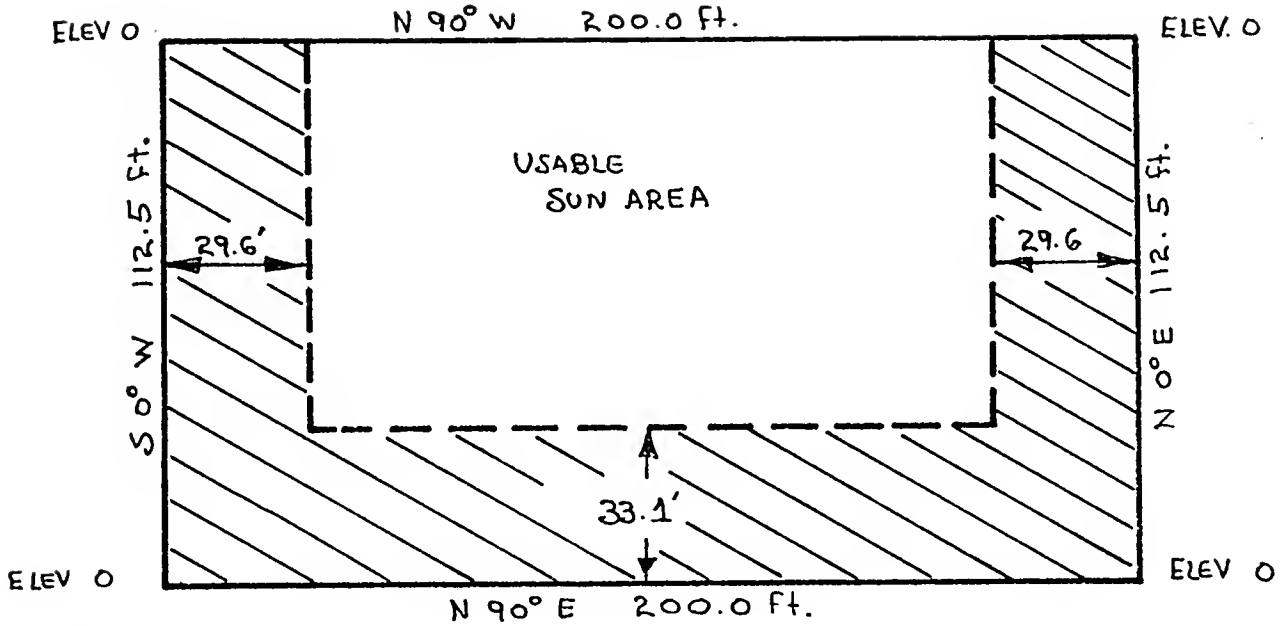
**********

#6 150 FT SQR SLOPE 8% NORTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10028.4 | 10046.5 | 46.5 | 10:00 AM DEC 21 |
| 2 | 10 | 10108.2 | 10046.5 | 41.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10108.2 | 10150.0 | 0.0 | |
| 4 | 10 | 10028.4 | 10150.0 | 28.4 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8263.6 SQ FT. ( 0.19 ACRES)
PERCENT USABLE IS 36.7 %

FIGURE 11




SCALE: 1'=40'

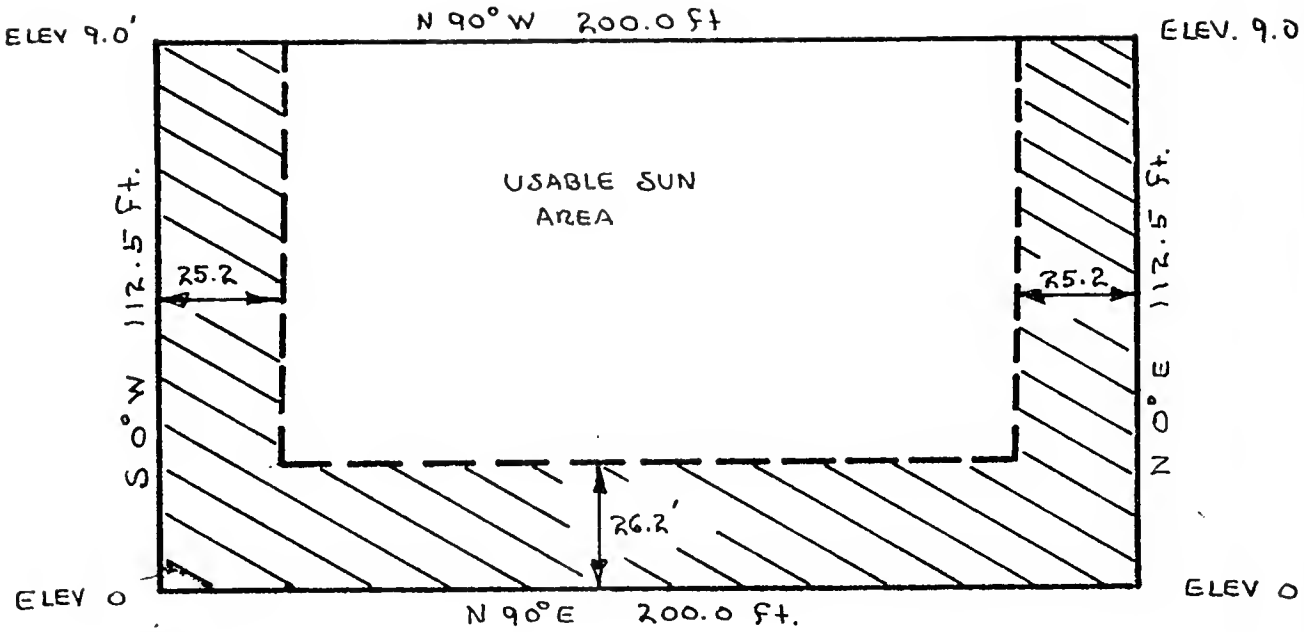
**********

#7 200 BY 112.5 LEVEL GROUND

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10029.6 | 10033.1 | 33.1 | 10:00 AM DEC 21 |
| 2 | 10 | 10170.4 | 10033.1 | 29.6 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10170.4 | 10112.5 | 0.0 | |
| 4 | 10 | 10029.6 | 10112.5 | 29.6 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 11176.8 SQ FT. ( 0.26 ACRES)
PERCENT USABLE IS 49.7 %

FIGURE 12




SCALE: 1"=40'

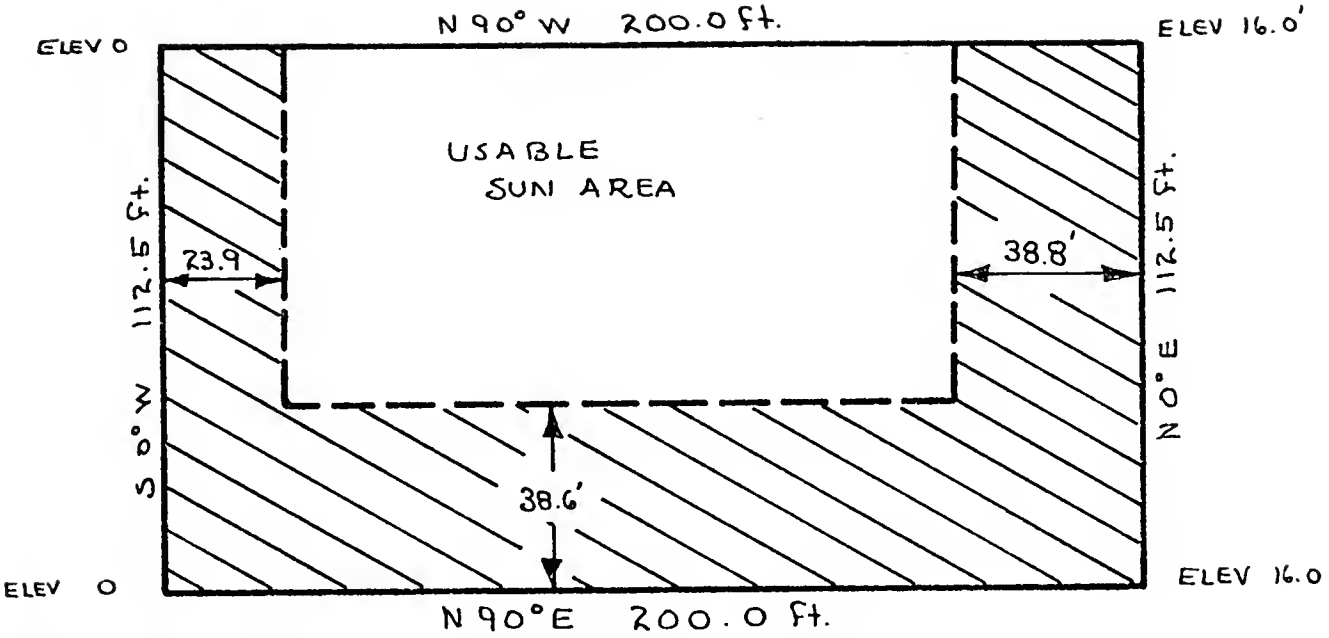
**********

#8 200 BY 112.5 SLOPE 8% SOUTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10025.2 | 10026.2 | 26.2 | 10:00 AM DEC 21 |
| 2 | 10 | 10174.8 | 10026.2 | 25.2 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10174.8 | 10112.5 | 0.0 | |
| 4 | 10 | 10025.2 | 10112.5 | 25.2 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 12912.6 SQ FT. ( 0.30 ACRES)
PERCENT USABLE IS 57.4 %

FIGURE 13




SCALE: 1"=40'

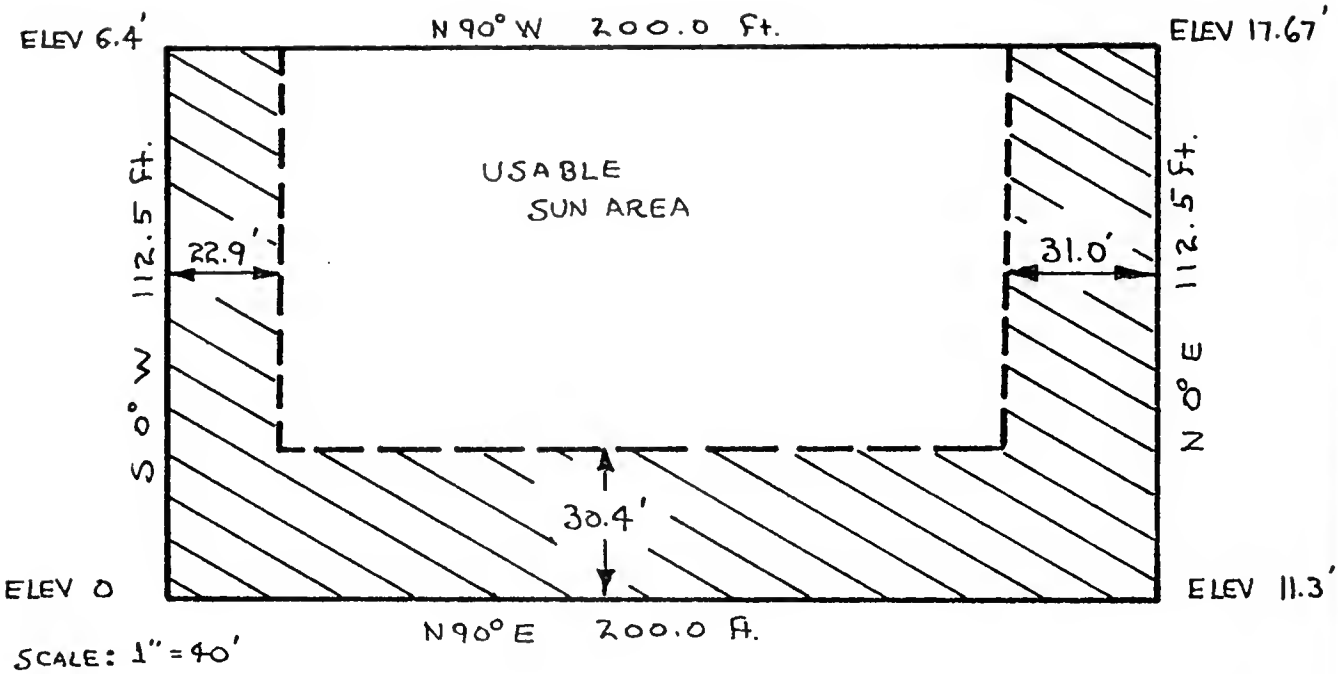
**********

#9 200 BY 112.5 SLOPE 8% WEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10023.9 | 10038.6 | 38.6 | 10:00 AM DEC 21 |
| 2 | 10 | 10161.2 | 10038.6 | 38.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10161.2 | 10112.5 | 0.0 | |
| 4 | 10 | 10023.9 | 10112.5 | 23.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 10142.0 SQ FT. ( 0.23 ACRES)
PERCENT USABLE IS 45.1 %

FIGURE 14



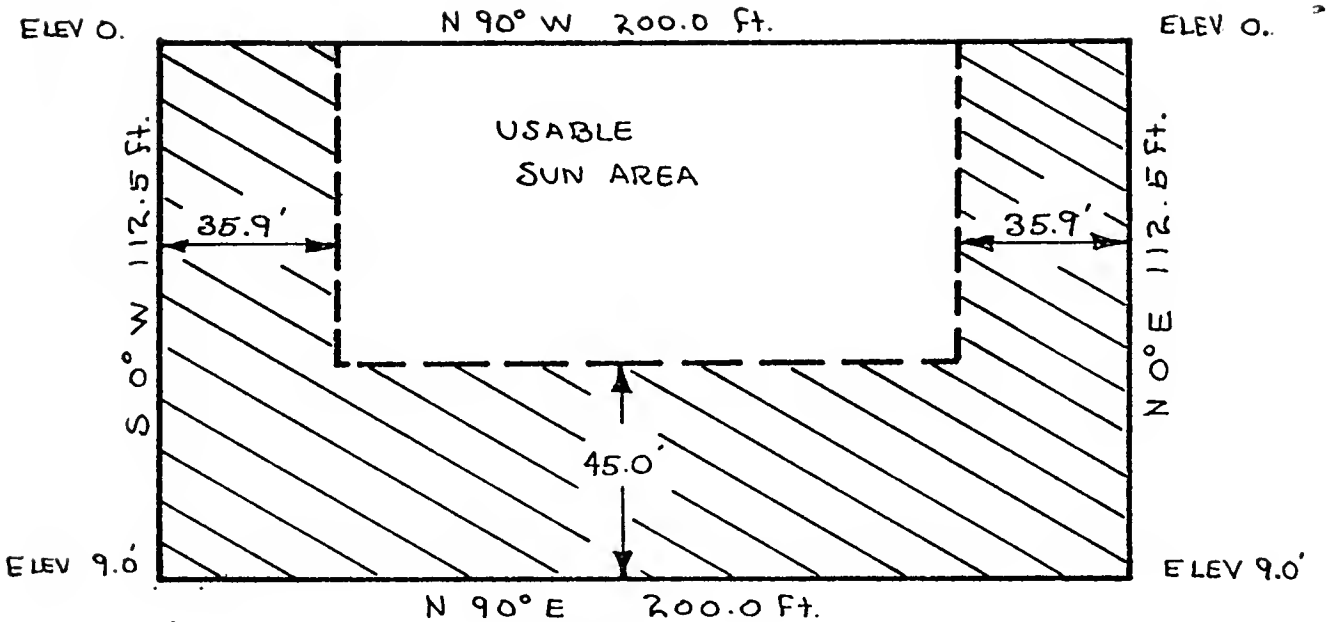

**********

#10 200 BY 112.5 SLOPE 8% SOUTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10022.9 | 10030.4 | 30.4 | 10:00 AM DEC 21 |
| 2 | 10 | 10169.0 | 10030.4 | 31.0 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10169.0 | 10112.5 | 0.0 | |
| 4 | 10 | 10022.9 | 10112.5 | 22.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 11988.5 SQ FT. ( 0.28 ACRES)
PERCENT USABLE IS 53.3 %

FIGURE 15




SCALE: 1" = 40'

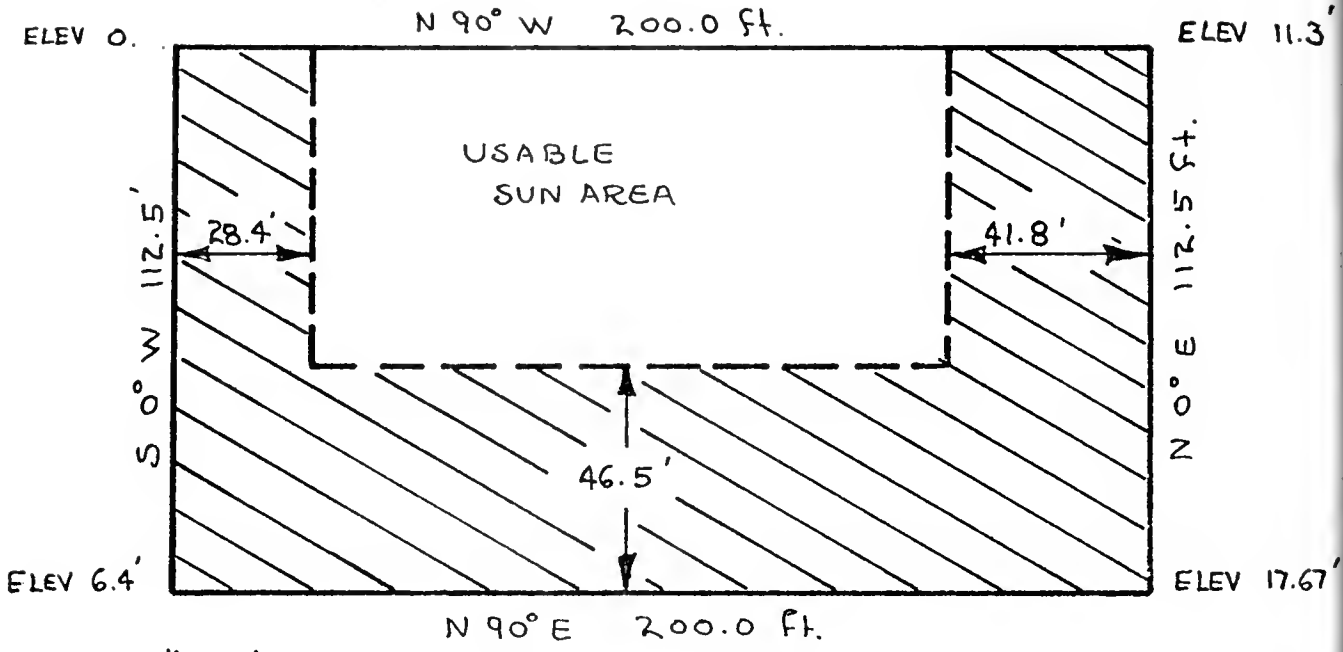
**********

#11 200 BY 112.5 SLOPE 8% NORTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10035.9 | 10045.0 | 45.0 | 10:00 AM DEC 21 |
| 2 | 10 | 10164.1 | 10045.0 | 35.9 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10164.1 | 10112.5 | 0.0 | |
| 4 | 10 | 10035.9 | 10112.5 | 35.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8653.2 SQ FT. ( 0.20 ACRES)
PERCENT USABLE IS 38.5 %

FIGURE 16




SCALE: 1" = 40'

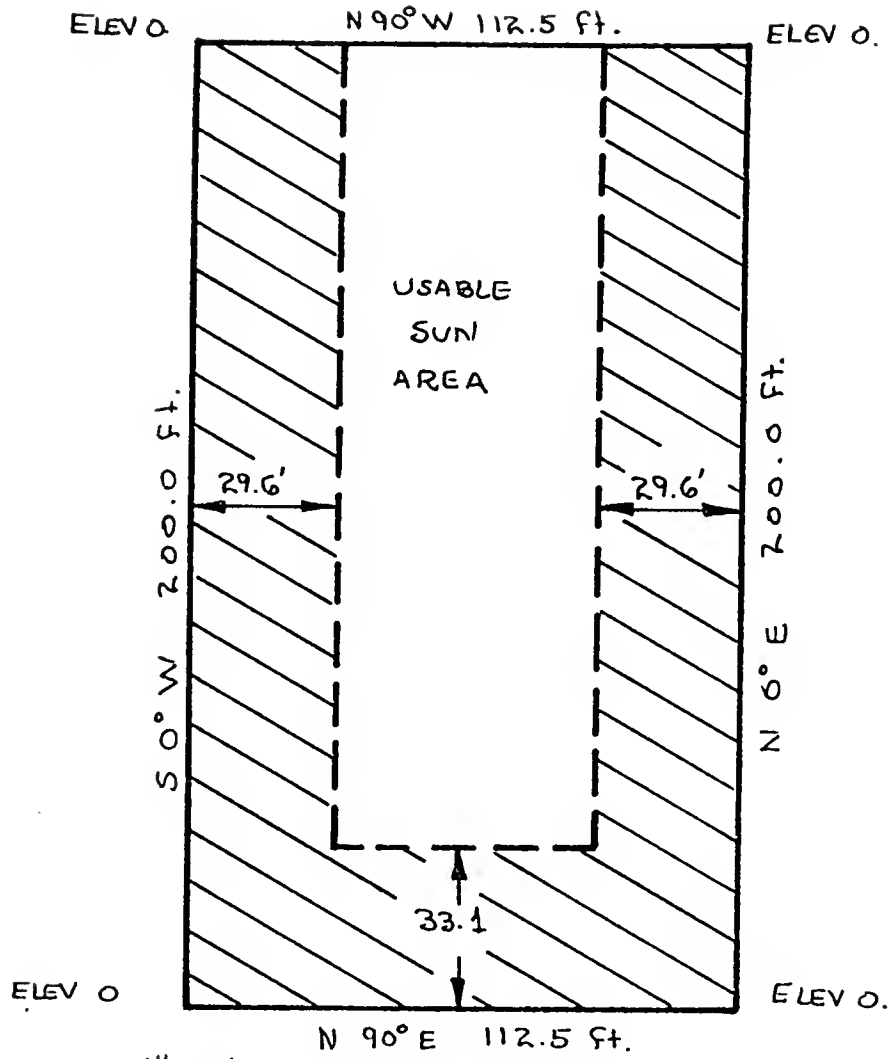
**********

#12 200 BY 112.5 SLOPE 8% NORTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10028.4 | 10046.5 | 46.5 | 10:00 AM DEC 21 |
| 2 | 10 | 10158.2 | 10046.5 | 41.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10158.2 | 10112.5 | 0.0 | |
| 4 | 10 | 10028.4 | 10112.5 | 28.4 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8565.2 SQ FT. ( 0.20 ACRES)
PERCENT USABLE IS 38.1 %

FIGURE 17




SCALE: 1" = 40'

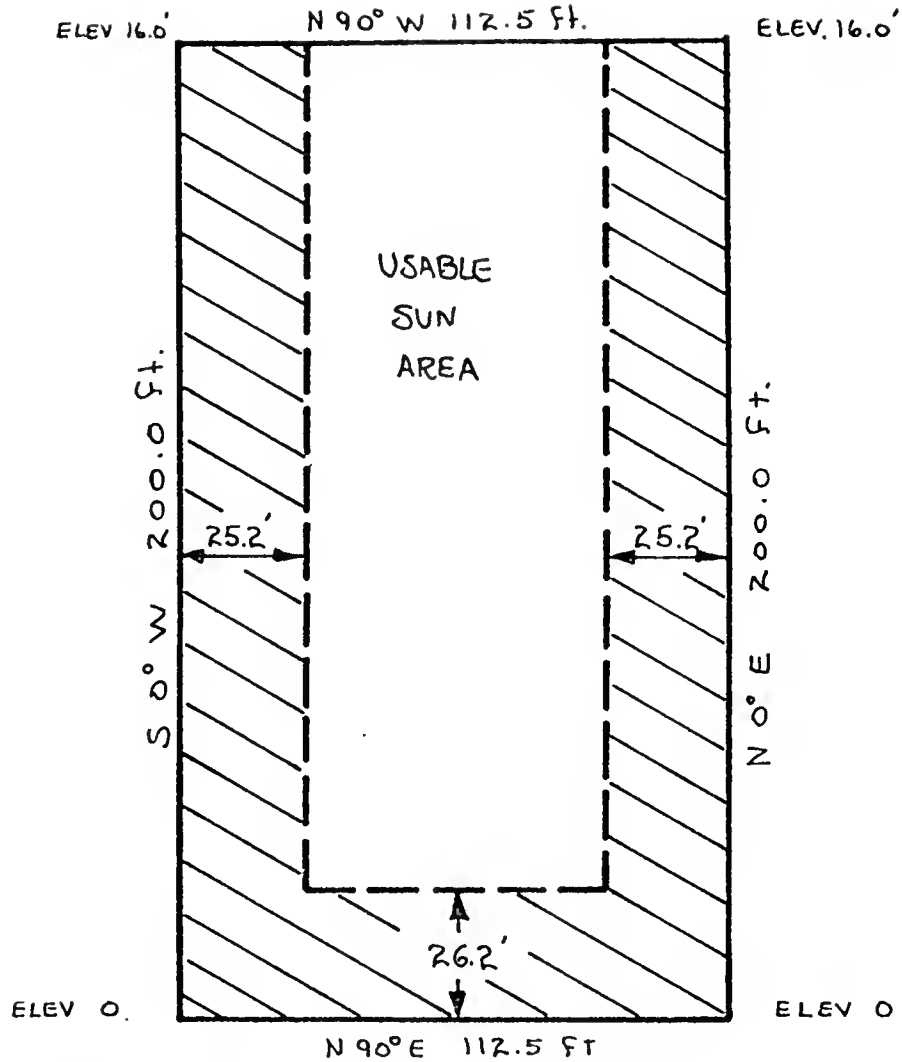
**********

#13 112.5 BY 200 LEVEL GROUND

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10029.6 | 10033.1 | 33.1 | 10:00 AM DEC 21 |
| 2 | 10 | 10082.9 | 10033.1 | 29.6 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10082.9 | 10200.0 | 0.0 | |
| 4 | 10 | 10029.6 | 10200.0 | 29.6 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8887.9 SQ FT. ( 0.20 ACRES)
PERCENT USABLE IS 39.5 %

FIGURE 18



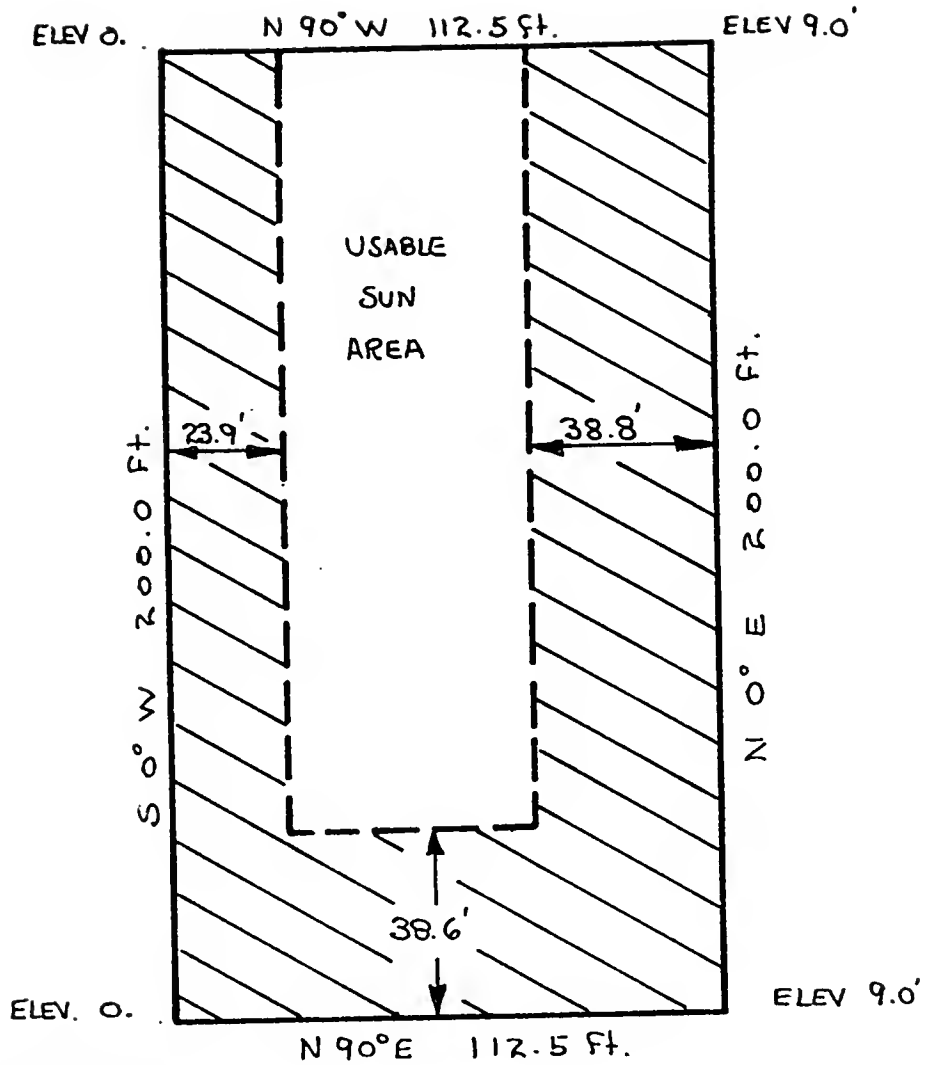

**********

#14 112.5 BY 200 SLOPE 8% SOUTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10025.2 | 10026.2 | 26.2 | 10:00 AM DEC 21 |
| 2 | 10 | 10087.3 | 10026.2 | 25.2 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10087.3 | 10200.0 | 0.0 | |
| 4 | 10 | 10025.2 | 10200.0 | 25.2 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 10788.7 SQ FT. ( 0.25 ACRES)
PERCENT USABLE IS 48.0 %

FIGURE 19




SCALE: 1"=40.0'

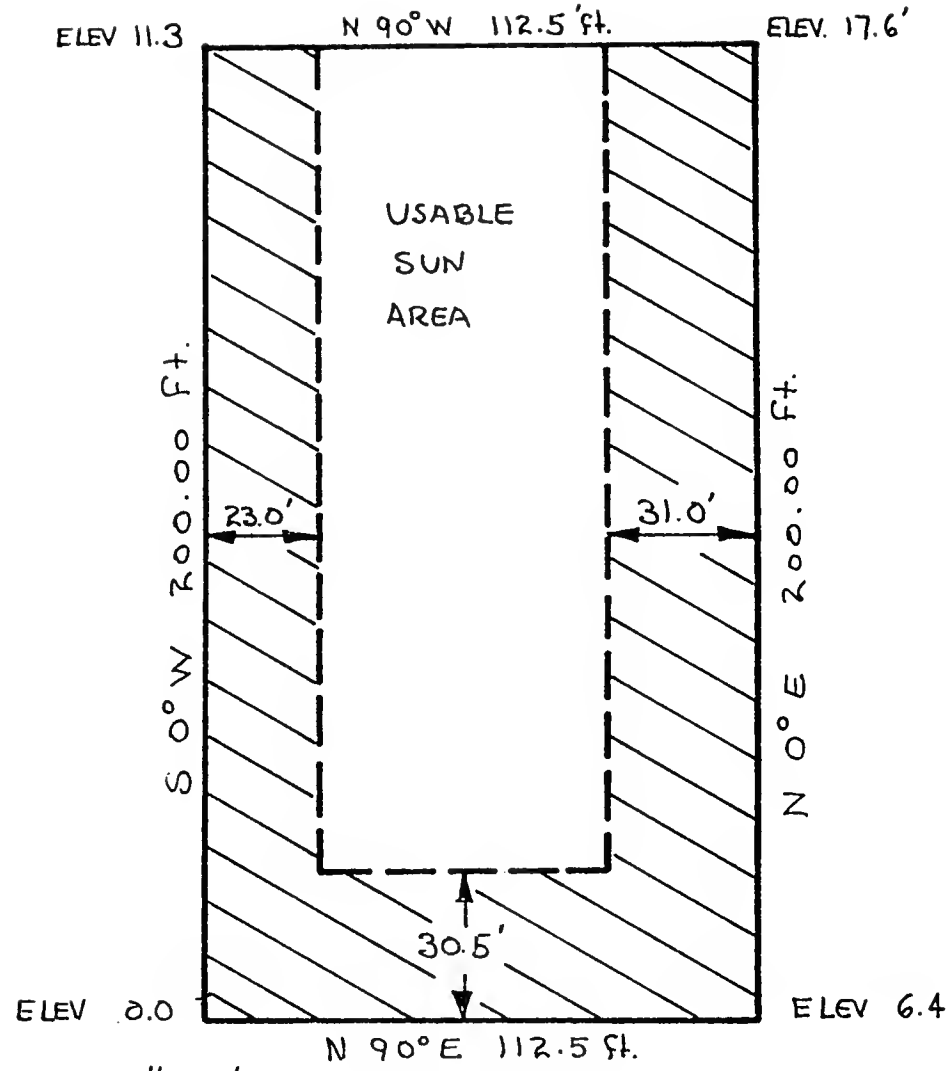
**********

#15 112.5 BY 200 SLOPE 8% WEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10023.9 | 10038.6 | 38.6 | 10:00 AM DEC 21 |
| 2 | 10 | 10073.7 | 10038.6 | 38.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10073.7 | 10200.0 | 0.0 | |
| 4 | 10 | 10023.9 | 10200.0 | 23.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 8025.8 SQ FT. ( 0.18 ACRES)
PERCENT USABLE IS 35.7 %

FIGURE 20




SCALE: 1" = 40'

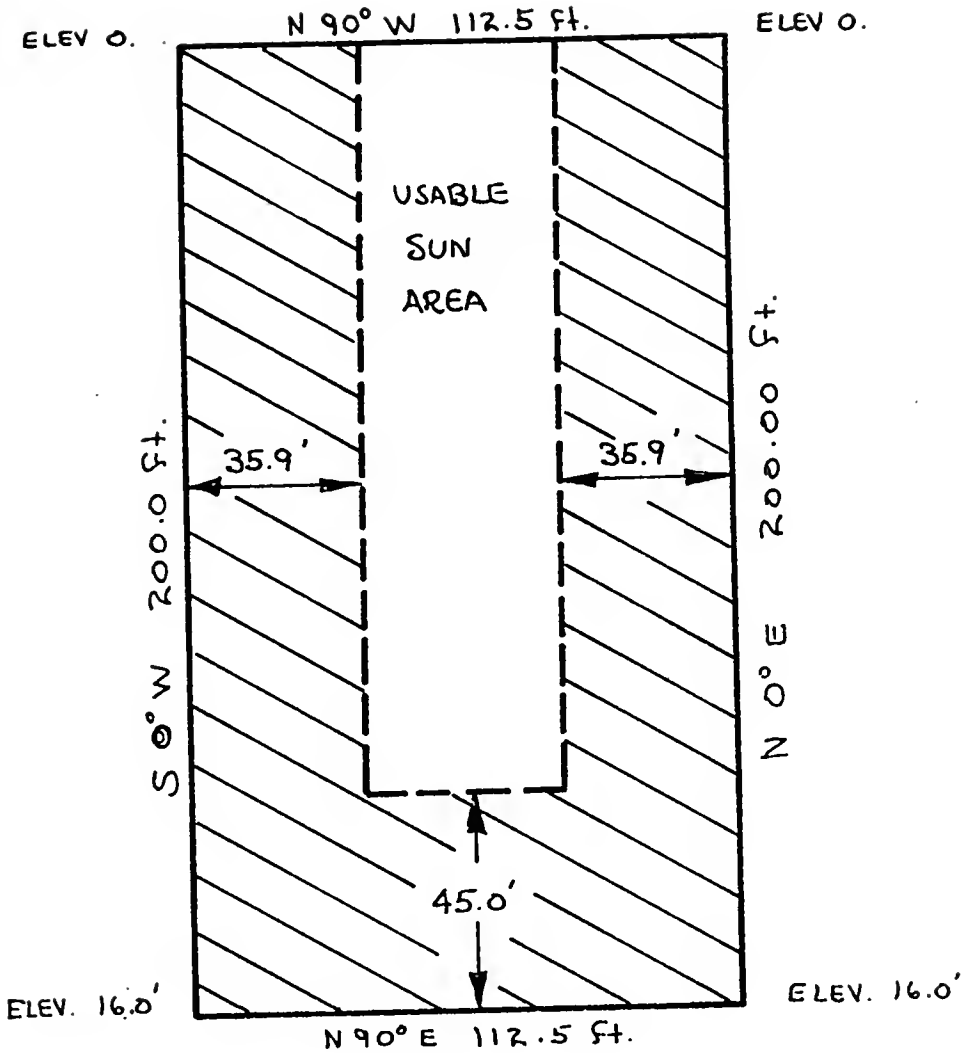
**********

#16 112.5 BY 200 SLOPE 8% SOUTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10023.0 | 10030.5 | 30.5 | 10:00 AM DEC 21 |
| 2 | 10 | 10081.5 | 10030.5 | 31.0 | 8:30 AM OCT OR FEB |
| 3 | 10 | 10081.5 | 10200.0 | 0.0 | |
| 4 | 10 | 10023.0 | 10200.0 | 23.0 | 3:30 PM OCT OR FEB |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 9916.4 SQ FT. ( 0.23 ACRES)
PERCENT USABLE IS 44.1 %

FIGURE 21




SCALE: 1" = 40'

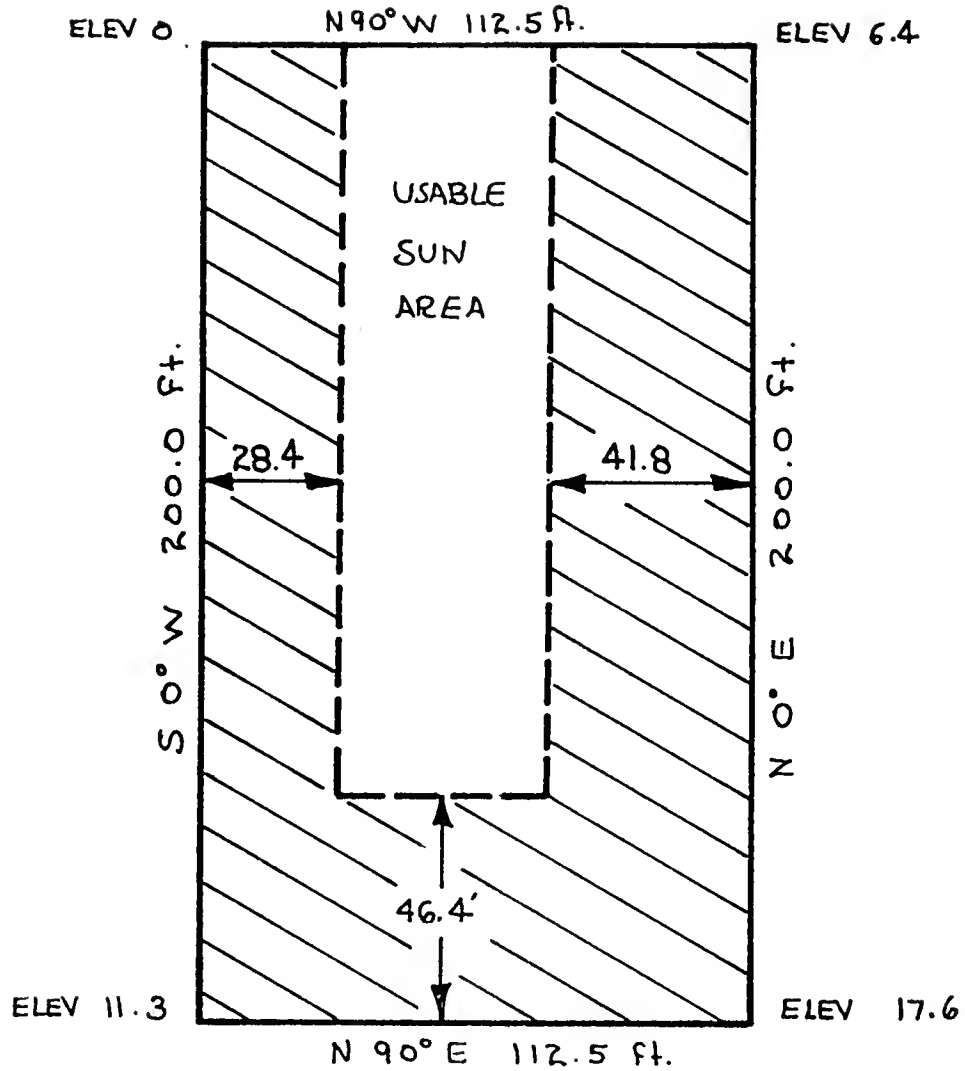
**********

#17 112.5 BY 200 SLOPE 8% NORTH

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10035.9 | 10045.0 | 45.0 | 10:00 AM DEC 21 |
| 2 | 10 | 10076.6 | 10045.0 | 35.9 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10076.6 | 10200.0 | 0.0 | |
| 4 | 10 | 10035.9 | 10200.0 | 35.9 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 6309.1 SQ FT. ( 0.14 ACRES)
PERCENT USABLE IS 28.0 %

FIGURE 22




SCALE: 1" = 40'

**********

#18 112.5 BY 200 SLOPE 8% NORTHWEST

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10028.4 | 10046.4 | 46.4 | 10:00 AM DEC 21 |
| 2 | 10 | 10070.7 | 10046.4 | 41.8 | 8:30 AM OCT OR FEB 2 |
| 3 | 10 | 10070.7 | 10200.0 | 0.0 | |
| 4 | 10 | 10028.4 | 10200.0 | 28.4 | 3:30 PM OCT OR FEB 2 |

TOTAL AREA OF THE LOT IS 22500.0 SQ FT. ( 0.52 ACRES)
LEFT OVER SUN AREA IS 6505.5 SQ FT. ( 0.15 ACRES)
PERCENT USABLE IS 28.9 %

FIGURE 23

Figure 24 is a plot of the per cent usable sun area versus the ground slope or tilt summarizing the results presented in Figures 6 through 23.

Generally speaking, the plot shows that lots roughly two times longer in the eastwest direction than the north-south direction offer the most usable sun area in all slope directions. The plot shows that square lots have only a slight (2 or 3 per cent) reduction in this usable sun area. A more significant reduction (10 per cent) in usable sun area is demonstrated for lots having northsouth lengths two times longer than the eastwest lengths. The best condition is the 200 by 112.5 foot lot sloping due south, whereas the worst condition is the 112.5 by 200 foot lot sloping due north.

# LEFT OVER USABLE SUN AREA VRS. GROUND TILT

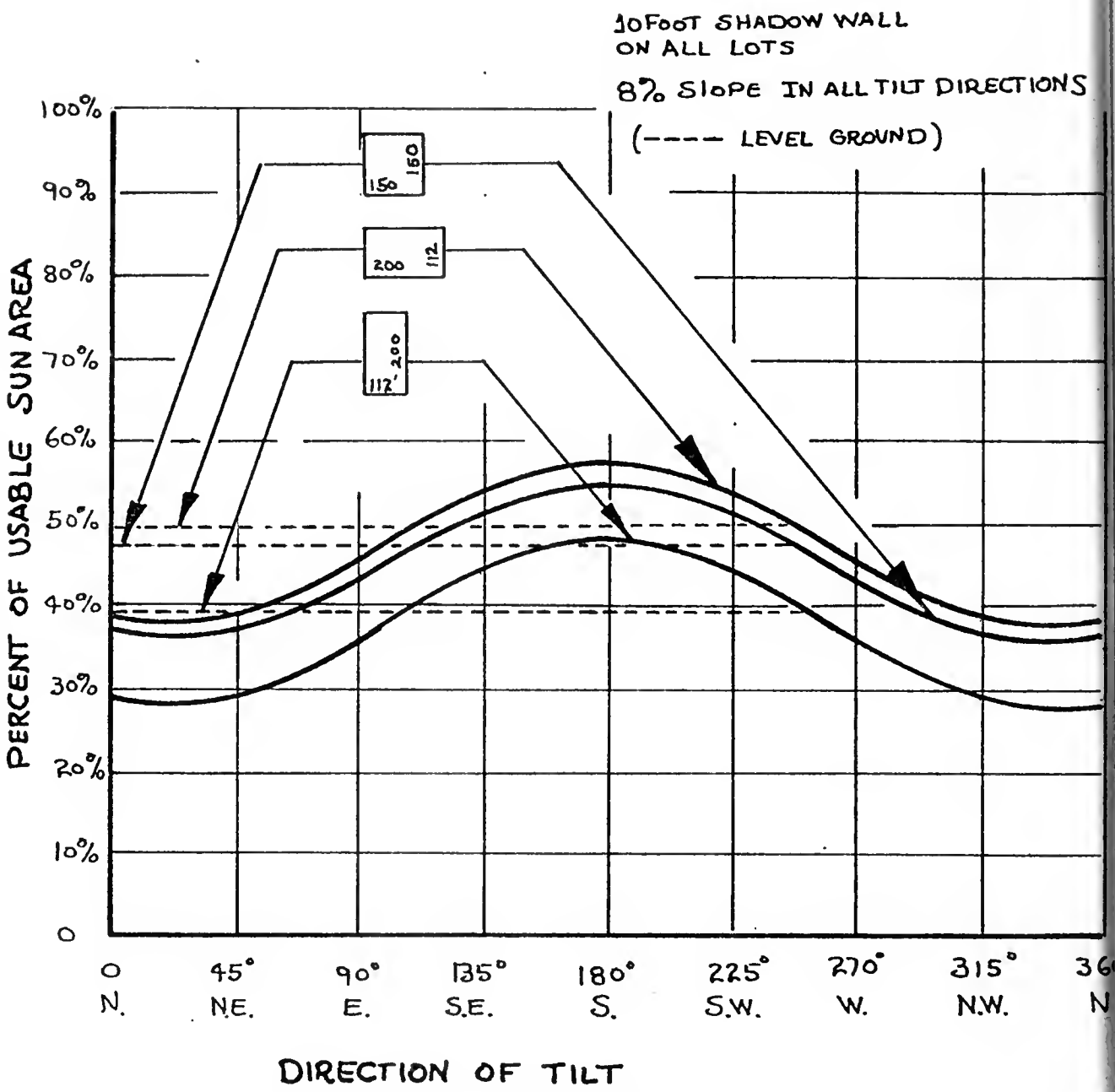



FIGURE 24

## 2.4 The Method Applied to a Proposed Subdivision

The proposed subdivision is located approximately three miles northwest of Helena, lying north of the Franklin Mine Road and south of the base of Scratch Gravel Hills. Appendix D shows a general vicinity map of its location.

For the most part, the land has a gentle slope southward and slightly eastward. This can be seen by observing the contour map in Appendix C.

The method developed in Chapter 2 was applied to this subdivision. The computer output is at the end of this section.

The parameters chosen for the analysis are discussed in the following:

1. Shadow Wall Heights:

   The southern end of the subdivision is bordered by one residential lot and the Lewis & Clark sanitary landfill. The landfill will necessarily be closed in the near future due to the fact that it is near its capacity. The future of this land then is uncertain, although there are rumors that a public park will be developed on it. The land due east and due west of the subdivision is privately owned and its development will be uncertain. However, this property lies within the Green Meadow study area, and, if the guidelines in this study are followed, the future of this land will be two acre or greater residential lots. Nevertheless, there are some uncertainties as to the future development, so 20 foot shadow wall parameters were used in the analysis for all lot sides bordering the

south, east and west sides of the subdivision. The land north of the subdivision begins to rise steeply into the Scratch Gravel Hills, and the ownership is partly BLM and privately owned mining claims. It appears that the future use of this land will not change and will affect the shadow analysis only slightly for the north lot sides which have bearing directions other than eastwest. These sides were given shadow wall heights of 10 feet. Any lot sides that divided adjacent lots within the subdivision were given shadow wall heights of 15 feet. Lot sides which border the subdivision 60 foot right-of-way were given lower shadow wall heights of 10 feet.

2. Ground Elevation:

Ground elevations were estimated to the nearest foot from the contour map in Appendix C and input for each lot corner.

3. Lot Bearings and Distances:

The lot sides bearings and distances were input beginning at the most southwest corner and proceeding counter clockwise around each lot. The values were taken directly from the preliminary plat (Appendix A). The current computer algorithm does not have a provision to handle curved lot sides so the curved portions were replaced by their chord distance and bearings. This will cause negligible error due to the relative size of the circular portions to the overall lot sizes.

4. Sun Angles:

The set of 17 critical sun angles presented in Table 4 were used for the analysis.

The results of the analysis are plotted on a solar easement overlay (Appendix B). This overlay is intended to be submitted with the plat for recording at the county seat. Note that the north property line for Lot No. 1 is made up of six different surveyed lines. These are sides 3 through 8 on the computer output results, and the setback distances computed are relatively small. The largest setback distance of 11.1 feet was used for these six surveyed lines to avoid cluttering the overlay with many insignificant setback dimensions. This procedure was used for the other lots having the same situations. Note also that the setback distances on the overlay are rounded to the nearest foot. The overlay is directly referred to in the legal description and is an important and necessary part of the solar easement agreement (see 3.3.4 Model Form for a Solar Easement). The owner or grantee of Lot #2, for example, can clearly see from this overlay the protected area of his lot and for what time periods throughout the year this protection is enforceable. Considering the south line of Lot #2 the grantor which would be the landowner south of Lot #2 can see that he is obligated to shadow Lot #2 not more than 71 feet during the time periods in the table shown on the overlay. The shadow wall height of 20 feet would indicate to the grantor that he can have objects as high as 20 feet directly against the property boundary.

For the most likely activities that the grantor may undertake on his property this information would be sufficient for him to proceed with confidence that he will not encroach on the airspace he has granted to the owner of Lot #2. It may or may not be obvious to the grantor that he can have objects higher

than 20 feet if they are located further south from the property line. The question arises as to how much higher and further south these values may be. If the grantor wishes to build something unusually high it would be necessary for him to obtain professional advice from either a registered engineer or surveyor to determine these values.

**********

LOT #1

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 10177.8 | 10068.9 | 67.5 | 2:00 PM DEC 21 |
| 2 | 15 | 10621.6 | 10072.4 | 39.5 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10619.6 | 10322.2 | 1.8 | 4:00 PM JUNE 21 |
| 4 | 10 | 10590.7 | 10316.4 | 4.4 | 4:00 PM JUNE 21 |
| 5 | 10 | 10410.4 | 10241.8 | 6.7 | 4:00 PM JUNE 21 |
| 6 | 10 | 10350.1 | 10202.0 | 11.1 | 4:00 PM SEPT OR MAR 21 |
| 7 | 10 | 10295.9 | 10148.8 | 3.5 | 4:00 PM JUNE 21 |
| 8 | 10 | 10170.0 | 10065.6 | 4.2 | 4:00 PM JUNE 21 |

TOTAL AREA OF THE LOT IS 116375.3 SQ FT. ( 2.67 ACRES)
LEFT OVER SUN AREA IS 64454.0 SQ FT. ( 1.48 ACRES)
PERCENT USABLE IS 55.4 %

**********

LOT #2

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 10049.7 | 10071.1 | 70.7 | 2:00 PM DEC 21 |
| 2 | 15 | 10227.6 | 10072.5 | 39.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10225.6 | 10328.6 | 0.0 | 4:00 PM JUNE 21 |
| 4 | 15 | 10047.7 | 10327.2 | 50.3 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 87577.1 SQ FT. ( 2.01 ACRES)
LEFT OVER SUN AREA IS 45565.7 SQ FT. ( 1.05 ACRES)
PERCENT USABLE IS 52.0 %

**********

LOT #3

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 10049.7 | 10071.1 | 70.7 | 2:00 PM DEC 21 |
| 2 | 15 | 10227.6 | 10072.5 | 39.8 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10225.6 | 10328.6 | 0.0 | 4:00 PM JUNE 21 |
| 4 | 15 | 10047.7 | 10327.2 | 50.3 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 87577.1 SQ FT. ( 2.01 ACRES)
LEFT OVER SUN AREA IS 45565.7 SQ FT. ( 1.05 ACRES)
PERCENT USABLE IS 52.0 %

**********

LOT #4

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 10047.9 | 10069.5 | 69.2 | 2:00 PM DEC 21 |
| 2 | 15 | 10226.4 | 10070.9 | 41.0 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10224.4 | 10328.6 | 0.0 | 4:00 PM JUNE 21 |
| 4 | 15 | 10045.9 | 10327.2 | 48.5 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 87577.1 SQ FT. ( 2.01 ACRES)
LEFT OVER SUN AREA IS 45987.3 SQ FT. ( 1.06 ACRES)
PERCENT USABLE IS 52.5 %
**********

LOT #5

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 10049.5 | 10071.1 | 70.7 | 2:00 PM DEC 21 |
| 2 | 20 | 10072.8 | 10071.3 | 69.9 | 9:30 AM NOV OR JAN 21 |
| 3 | 15 | 10399.5 | 10389.2 | 14.9 | 8:00 AM SEPT OR MAR 21 |
| 4 | 10 | 10297.1 | 10494.4 | 11.0 | 4:00 PM SEPT OR MAR 21 |
| 5 | 10 | 10209.7 | 10409.3 | 4.3 | 4:00 PM JUNE 21 |
| 6 | 15 | 10047.4 | 10342.7 | 50.1 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 126319.0 SQ FT. ( 2.90 ACRES)
LEFT OVER SUN AREA IS 68457.2 SQ FT. ( 1.57 ACRES)
PERCENT USABLE IS 54.2 %
**********

LOT #6

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 20 | 9995.5 | 10098.9 | 74.0 | 9:30 AM NOV OR JAN 21 |
| 2 | 20 | 10213.2 | 10310.7 | 16.2 | 8:00 AM SEPT OR MAR 21 |
| 3 | 15 | 10086.7 | 10420.4 | 16.9 | 4:00 PM SEPT OR MAR 21 |
| 4 | 10 | 9893.0 | 10231.9 | 23.0 | 3:30 PM OCT OR FEB 21 |
| 5 | 15 | 9885.2 | 10212.2 | 65.7 | 2:30 PM NOV OR JAN 21 |

TOTAL AREA OF THE LOT IS 97226.9 SQ FT. ( 2.23 ACRES)
LEFT OVER SUN AREA IS 49415.1 SQ FT. ( 1.13 ACRES)
PERCENT USABLE IS 50.8 %
**********

LOT #7

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10042.1 | 10048.7 | 31.4 | 10:00 AM DEC 21 |
| 2 | 15 | 10016.9 | 10039.5 | 46.5 | 9:30 AM NOV OR JAN 21 |
| 3 | 20 | 10240.6 | 10257.2 | 14.4 | 8:00 AM JULY OR MAY 21 |
| 4 | 10 | 10025.4 | 10443.9 | 11.8 | 4:00 PM SEPT OR MAR 21 |
| 5 | 15 | 9837.7 | 10258.7 | 64.1 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 120374.9 SQ FT. ( 2.76 ACRES)
LEFT OVER SUN AREA IS 77893.0 SQ FT. ( 1.79 ACRES)
PERCENT USABLE IS 64.7 %

**********

LOT #8

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10052.5 | 10035.8 | 35.4 | 2:00 PM DEC 21 |
| 2 | 10 | 10267.5 | 10037.5 | 33.0 | 10:00 AM DEC 21 |
| 3 | 10 | 10399.1 | 10091.5 | 33.8 | 9:30 AM NOV OR JAN 21 |
| 4 | 15 | 10495.9 | 10185.6 | 13.8 | 8:00 AM SEPT OR MAR 21 |
| 5 | 10 | 10312.9 | 10373.7 | 13.6 | 4:00 PM SEPT OR MAR 21 |
| 6 | 10 | 10196.2 | 10258.5 | 9.2 | 8:00 AM SEPT OR MAR 21 |
| 7 | 10 | 10105.2 | 10352.0 | 0.0 | 4:00 PM JUNE 21 |
| 8 | 15 | 10050.1 | 10351.2 | 52.7 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 148291.8 SQ FT. ( 3.40 ACRES)
LEFT OVER SUN AREA IS 104969.9 SQ FT. ( 2.41 ACRES)
PERCENT USABLE IS 70.8 %

**********

LOT #9

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10045.1 | 10029.8 | 29.5 | 2:00 PM DEC 21 |
| 2 | 15 | 10232.6 | 10031.3 | 35.1 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10230.1 | 10352.1 | 0.0 | 9:30 AM NOV OR JAN 21 |
| 4 | 15 | 10042.6 | 10349.3 | 45.3 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 93678.5 SQ FT. ( 2.15 ACRES)
LEFT OVER SUN AREA IS 60039.9 SQ FT. ( 1.38 ACRES)
PERCENT USABLE IS 64.1 %

**********

LOT #10

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10042.9 | 10028.8 | 28.5 | 2:00 PM DEC 21 |
| 2 | 15 | 10232.7 | 10030.3 | 35.1 | 8:30 AM OCT OR FEB 21 |
| 3 | 10 | 10230.2 | 10350.2 | 0.0 | 9:30 AM NOV OR JAN 21 |
| 4 | 15 | 10040.4 | 10347.4 | 43.1 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 93176.0 SQ FT. ( 2.14 ACRES)
LEFT OVER SUN AREA IS 60585.7 SQ FT. ( 1.39 ACRES)
PERCENT USABLE IS 65.0 %

**********

LOT # 11

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10038.8 | 10048.2 | 29.7 | 10:00 AM DEC 21 |
| 2 | 10 | 10076.7 | 10063.9 | 28.3 | 10:00 AM DEC 21 |
| 3 | 15 | 10161.7 | 10081.1 | 35.2 | 8:30 AM OCT OR FEB 21 |
| 4 | 10 | 10159.2 | 10405.6 | 0.0 | 3:30 PM OCT OR FEB 21 |
| 5 | 15 | 9892.8 | 10401.7 | 54.3 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 105835.0 SQ FT. ( 2.43 ACRES)
LEFT OVER SUN AREA IS 67014.8 SQ FT. ( 1.54 ACRES)
PERCENT USABLE IS 63.3 %

**********

LOT #12

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10015.6 | 10061.2 | 32.8 | 8:30 AM OCT OR FEB 21 |
| 2 | 10 | 10000.2 | 10046.1 | 31.7 | 9:30 AM NOV OR JAN 21 |
| 3 | 10 | 10095.5 | 10109.1 | 30.8 | 10:00 AM DEC 21 |
| 4 | 15 | 10164.8 | 10137.7 | 26.9 | 8:00 AM SEPT OR MAR 21 |
| 5 | 10 | 10006.9 | 10519.8 | 0.0 | 3:30 PM OCT OR FEB 21 |
| 6 | 20 | 9693.2 | 10515.2 | 17.9 | 4:00 PM SEPT OR MAR 21 |
| 7 | 15 | 9630.2 | 10454.1 | 54.1 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 181092.2 SQ FT. ( 4.16 ACRES)
LEFT OVER SUN AREA IS 130357.7 SQ FT. ( 2.99 ACRES)
PERCENT USABLE IS 72.0 %

**********

LOT #13

| SIDE | WALL HT. (FT.) | COORDINATES X | Y | SETBACK (FT) | CONTROLLING SUN ANGLE |
|---|---|---|---|---|---|
| 1 | 10 | 10075.5 | 10031.1 | 32.6 | 2:00 PM DEC 21 |
| 2 | 10 | 10001.9 | 10032.7 | 32.4 | 10:00 AM DEC 21 |
| 3 | 10 | 10070.0 | 10046.5 | 33.6 | 10:00 AM DEC 21 |
| 4 | 10 | 10191.1 | 10096.6 | 33.7 | 9:30 AM NOV OR JAN 21 |
| 5 | 10 | 10256.8 | 10140.1 | 33.5 | 9:30 AM NOV OR JAN 21 |
| 6 | 15 | 10284.5 | 10167.2 | 14.8 | 8:00 AM SEPT OR MAR 21 |
| 7 | 20 | 9901.5 | 10557.6 | 21.0 | 4:00 PM SEPT OR MAR 21 |
| 8 | 20 | 9727.4 | 10388.6 | 75.7 | 3:30 PM OCT OR FEB 21 |

TOTAL AREA OF THE LOT IS 189120.6 SQ FT. ( 4.34 ACRES)
LEFT OVER SUN AREA IS 127078.9 SQ FT. ( 2.92 ACRES)
PERCENT USABLE IS 67.2 %

## 2.5 Conclusions to the Technical Development:

The shadow analysis in this report assumes that the area being analyzed is free from shadow caused by nearby mountain ranges. A similar analysis method could first determine on a macro-scale whether the region in question gets shadow for sun altitudes of 15 degrees or greater. These results may effect then a different set of yearly critical sun angles to use for the shadow analysis. Special care would have to be made with this method for areas lying at the base of north sloped mountainous areas or lying in relatively steep mountain valleys. Canyons lying generally in the northsouth directions may have as little as three hours of direct sunlight in December. It is possible that some lots are just not suitable at all for creating solar easement rights.

The method presented probably has little use for lots any smaller than one-half acre. At this point one would have to approach the problem more on a micro-scale, dealing with points of actual location of trees and houses, etc. The shadow wall concept would not be suitable for these areas.

The method presented demonstrates the difficulty and complexity encountered in deriving the geometry which defines directly the air-space over the grantor's property. This complexity is greatly reduced by describing the protected area for the grantee as was done in the method presented, which in turn implies or indirectly describes the airspace over the grantor's property. This is belived to be the best approach, since it clearly defines the grantor's obligations while simultaneously clearly defining the grantee's protected area. This, however, is at the expense of a simple interpretation of the granted

airspace. In the cases where relatively high structures are planned on the grantor's property, a qualified person will have to be consulted to determine if the structure will encroach on this airspace.

# CHAPTER 3

# SOLAR EASEMENT - LEGAL

## 3.1 Introduction:

It is important at the outset to note the limitations of the legal analysis which follows. For the purposes of this project, the legal aspects of solar easements were examined in relation to new subdivisions in Montana, which is designed to be divided into one-half acre or larger lots for residential purposes. Therefore, little attention will be paid to problems which might arise in other states or urban areas.

The analysis is intended to be a general and practical survey of how a Montanan can get the right to receive sunlight which shines over someone else's land. Although the analysis assumes that the landowner who wants this "right to light" has some sort of active or passive solar energy device, it is also possible that a landowner with a traditional home might want to know that he has a guaranteed amount of sunlight.

## 3.2 What is an Easement?

Traditional property law defines an easement as an interest in land which is in the possession of someone else and gives the owner of the interest a limited use or enjoyment of that land. Restatement of Property 450 (1944). In the case of a solar ease-

ment, we are talking about a landowner having the right to a certain amount of air space over someone else's property which guarantees that he receives unobstructed sunlight. In other words, the landowner who gives (or sells) a solar easement, is forbidden from doing anything on his land which would create a shadow on some specified part of his neighbor's land.

## 3.3 How to Create a Solar Easement:

### 3.3.1 General Considerations:

As with any grant of a property interest, the grant of a solar easement requires a definition of the right conveyed which is unambiguous and explicit, an initial assignment of the right, and a method of enforcing the right. How these requirements are met, whether through an express grant, a covenant, a reservation or exception in a conveyance, is not important legally.

### 3.3.2 Montana Laws Directly Relating to Solar Easements:

> 70-17-101, MCA. Servitudes attached to land. The following land burdens or servitudes upon land may be attached to other land as incidents or appurtenances are then called easements:
>
> ***
>
> (8) the right of receiving air, light, or heat from or over or discharging the same upon or over land;

> CHAPTER NO. 524
> Session Laws, 1979
> Codified at 70-17-301 and 70-17-302
>
> AN ACT TO PROVIDE FOR THE CREATION AND CONVEYANCING OF SOLAR EASEMENTS.
>
> Be it enacted by the Legislature of the State of Montana:
>
> Section 1. Solar easement--creation. An easement obtained for the purpose of exposure

of a solar energy device must be created in writing and is subject to the same conveyancing and instrument recording requirements as other easements on real property.

Section 2. Solar easement--contents. An instrument creating a solar easement must specify at least:

(1) the vertical and horizontal angles, expressed in degrees, at which the solar easement extends over the real property subject to the solar easement; and

(2) any terms or conditions under which the solar easement is granted or will be terminated.

Approved April 10, 1979.

Section 70-17-101(8) solved many of the problems created by traditional common law property theories, which tended to limit the rights of a landowner who receives the right to sunshine from someone else's property. However, Chapter 524, Session Laws, 1979, has created some real legal problems in carrying out the solar rights scheme contemplated by the technical part of this report. That scheme contemplates access to sun for a specific area of the easement owner's land; whatever use the owner wishes to put that access is up to him, whether it be for active or passive solar heating systems, a garden or mere aesthetics, and is intended to last through any ownership change and any change or nonuse of the solar rights granted. By contrast, Chapter 524 contemplates an easement only for "the purpose of exposure of a solar energy device". Under traditional easement law, an easement may be determined by a court to be abandoned, and therefore lost, if it is no longer used for the purpose for which it is granted. If this law were applied under Chapter 524, a court might find that the easement had been terminated because the owner had failed to

install a solar energy device. Such a result is possible even if a solar device was built if it was then dismantled and not replaced.

This problem arises because, in the past, easements for light were often secured for a particular building, or even a particular window in a building. When subsequent events, such as destruction of the building or permanent boarding up of the window, made the easement of little or no use, the easement was determined to be terminated.

Unfortunately, a traditional interpretation of a solar easement could draw the analogy that the solar energy device is like a window. Wording in the Model Solar Easement is intended to lessen the possibility of such an interpretation. These problems highlight the benefit of defining a solar easement according to the land benefited, rather than according to a particular building or solar energy device.

Another problem raised by Chapter 524 for the solar easements contemplated by this report is the requirement that the easement must specify "the vertical and horizontal angles, expressed as degrees, at which the solar easement extends over the real property subject to the solar easement....". The scheme proposed by the technical portion of this report anticipates no specific limitations on any particular portion of the burdened land; the owner can create any obstruction on any part of his land as long as it does not cast a shadow in the protected area for the specified hours of the day throughout the year. Under the scheme proposed in this report for protection of solar access, it is impossible to meet the horizontal and vertical angles requirement of Chapter 524. Such a definition, designed to meet the Chapter 524

requirements, is possible only if the easement is designed to protect a specific solar device located at a specific location. For reasons already discussed, it is questionable whether such an approach is advisable.

Because of these problems, the Model Solar Easement Form specifically notes that the easement will be enforced under the terms of Section 70-17-101, MCA.

3.3.3 Meeting Other Requirements of Montana Law:

1. A solar easement must be in writing.

This requirement is obvious. The only comment legally, is that this requirement excludes a claim that, since a landowner has received sunlight from over someone else's property in the past, he is entitled to that sunlight which comes over another's land in the future. In legal terms, a solar easement cannot be secured through adverse possession.

2. A solar easement is subject to conveyancing (transferring) and recording requirements.

a. Montana's legal requirements for transferring (conveyancing) property are found in Section 70, Chapter 20, MCA.

b. Montana's legal requirements for recording transfers of property are found in Title 70, Chapter 21, MCA. This title sets forth the following requirements for those who wish to give or get solar easements:

---Any document affecting possession of real estate may be recorded (70-21-201, MCA);

---Before an easement can be recorded, it must be acknowledged by the person executing it (70-21-203, MCA).

---Easements must be recorded by the county clerk of the county in which the real estate is located (70-21-208, MCA).

When an easement is recorded, the law says that subsequent purchasers and mortgagors are assumed to know that there is an easement on the property, (70-21-302, MCA). However, if the easement is not recorded, it will not be enforced if the subsequent landowner does not actually know his land is subject to an easement or if there is a recorded document which is in conflict with the solar easement, (70-21-304, MCA).

### 3.3.4 Model Form for a Solar Easement:

----------, hereinafter called Grantor, is the owner of the following described property:

(Legal description of Grantor's property)

----------, hereinafter called Grantee, is the owner of certain property which shall be called the Solar Property, the following described portion of which shall be protected from any shadow as provided herein, and shown on the attached plat which is hereby incorporated as a part of this easement:

(Description of protected portion of Grantee's property)

Now, therefore, in consideration of One Dollar and other good valuable considerations, the receipt of which is hereby acknowledged, Grantor does hereby grant, bargain, sell and convey to Grantee, his heirs and assigns, in fee forever, an easement and right-of-way

for unobstructed access to direct sunlight in the airspace above the surface of Grantor's property described as follows:

> That airspace above the Grantor's property necessary to prevent any building, improvement, tree, landscaping or other obstruction of any kind or nature located on Grantor's property from casting a shadow on the protected portion of the Solar Property greater than the shadow cast by a vertical hypothetical wall, as specified on the attached Solar Easement overlay, located along the Solar Property line separating Grantor's and Grantee's property as described above, during the times specified on the attached Solar Easement overlay.

No building, tree or other obstruction of any kind or nature shall be allowed to encroach within the airspace described. This Solar Easement is an interest in land and shall run with the land benefited and burdened as appurtenances.

It is the intent of the parties that this easement be perpetual, and that it shall not be terminated by failure of Grantee, his heirs or assigns to construct and use a solar energy device. It is the intent of parties to this easement that, by this agreement, Grantee, his heirs and assigns, shall be assured unobstructed access to direct sunlight in that protected portion of the Solar Property, as described above, for whatever purposes he, his heirs, successors, or assigns, deem appropriate. Failure to use such rights granted by this easement in an obvious and open manner shall not be construed as abandonment of those rights or a bar to the transfer of those rights.

This easement may be enforced in law or equity by any party hereto or by any person or persons subsequently deriving title to the real property described in this declaration, or any portion thereof, from or through any party hereto or any successor in interest thereof.

That the said present owners, their heirs, administrators and assigns, and every person hereinafter having any right, title or interest in the aforedescribed land shall have the right to prevent or stop violation of this easement by injunction or other lawful procedure, and to recover any damages resulting from such violation, or from the enforcement of these restrictions, including reasonable attorney fees should resort be had to the Court for the enforcement hereof; the failure by these present owners, their heirs, administrators, or assigns, or by any person having any right, title or interest in and to the aforedescribed land, to enforce any restriction, condition, covenant, or agreement herein contained shall in no event be deemed a waiver of the right to do so thereafter as to the same breach or as to one occurring prior or subsequent thereto.

It is the intent of the parties that in any action to enforce this easement, Section 70-17-101, MCA, shall be the law to be applied.

This easement shall be binding on the heirs, successors and assigns of all parties.

IN WITNESS WHEREOF, the Grantor has hereunto set his hand and seal this-----day of ----------, 19--.

By:

---

Grantor

STATE OF----------)
) ss.
County of----------)

On this -----day of ----------, 19--, before me personally appeared----------, known to me to be the persons whose names are subscribed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

Witness my hand and official seal.

---

NOTARY PUBLIC

My commission expires:

---

3.3.5 Describing the Solar Easement:

Developing a legally enforceable description of what the Solar Easement encompasses is the most difficult problem for the legal draftsman. Except for Kraemer's SOLAR LAW (See legal Literature on Solar Easements), the current literature offers little if any assistance.

The problem encountered in properly defining the easement to reflect the work done for this report arose from the fact that the thrust of the project was to define the area to be protected, rather than the area to be limited, that is, the airspace which must be kept free for the flow of sunlight. Since this area could not be defined in specific terms, it was decided to also attach a plat which will show the area protected.

The description of an easement is extremely important and should be as definite as possible in relation to the rights and duties of respective parties. Courts may be reluctant to enforce easements which do not fairly put the

landowner, whose land is subject to the restrictions, on notice about what he can and cannot do. Whenever possible, the easement should describe the airspace over the land subject to the easement.

If the parties wish to agree to an easement which would protect a portion of the adjoining lot, as is contemplated by this report, the draftsman may wish to break the property subject to the easement into zones with height limitations for each zone. Kraemer, in SOLAR LAW, also suggests the possibility of what he calls a "solar plane easement", and provides a methodology for implementing it.

Whatever method is chosen, an attorney should work closely with an engineer or other qualified person to develop an unambiguous and easily understood definition of what rights and duties the easement grants.

Standard rules of interpreting documents which restrict use of land highlight the need for careful language

------limitations should be "strictly construed";

------ambiguities should be resolved in favor of a free use of property;

------courts should not impose limitations in terms of what the parties would have desired had they initially been confronted with questions later developing.

Higdem v Whitham
---
167 Mont. 201 (1975)

## 3.4 How to Guarantee Rights Granted by the Solar Easement-Enforcement:

The form proposed in Section 3.3.4 specifically spells

out the types of enforcement which might be available. For the landowner who wishes to continue to receive sunlight from over his neighbor's land, the action for an injunction is the only satisfactory enforcement tool. An injunction will prevent the landowner whose property is subject to an easement from doing anything on his land which interferes with the rights granted by the easement.

If only damages are granted, the owner will receive nothing but a monetary award for the value of the easement. The value would be determined by the court. In the case of a solar easement for a residential lot, this amount might be quite small, especially if the easement owner had not installed a solar energy device on the land.

Assuming that the owner of the easement wishes to continue to own it, rather than be reimbursed for its loss, it is extremely important that, if his neighbor takes any action which will shade the protected area, the easement owner take immediate legal action. Courts have held that delay, when it results in a substantial investment by the person who violates the easement, may be grounds for not granting a mandatory injunction. For example, if the owner of the solar easement learns that his neighbor is building a house which will shadow the protected area, watches his neighbor build the house, and then goes to court to get the obstruction removed, it is unlikely that the court will grant his request.

## 3.5 Termination of a Solar Easement:

Montana law, Section 70-17-111, MCA, sets out how solar

easements can be terminated:

-----when one person owns both the land subject to the easement and the land benefited by the easement;

-----when the land subject to the easement is destroyed;

-----when the owner of the land benefited by the easement does something or "assents to" another doing something which is imcompatible with the easement;

-----when the servitude was acquired "by enjoyment", by not using the right for the same period for acquiring title by enjoyment.

Under Montana case law, an easement may be lost by abandonment, that is, the landowner who owns an easement can decide he does not want that easement any more.

Park Co. Rod & Gun Club v State
163 Mont. 372

In order to lose the easement, though, a landowner must show a clear intent to abandon. The mere fact that the easement owner does not use the easement, for however long, does not mean that he has abandoned the rights he has because he owns the easement.

City of Billings v. O.E. Tel Co., 168 Mont. 264

The protection these court decisions give to an easement owner could be very important if applied literally by the courts to solar easements. For instance under these cases, if a person bought a piece of land with a solar easement, but did not build a house for several years, he would not lose the right to sunlight from his neighbor's land. Also, if a solar easement owner built a house on his land that did not take direct advantage of his "solar rights" nonetheless, he would continue to own them.

One obvious act of abandonment would be a written agreement signed by the easement owner that he no longer wished to own the easement.

In most cases, an easement cannot be terminated by oral agreement, although if the easement owner gives oral permission to his neighbor to shade the protected property and the neighbor does so, a court may decide the easement is terminated.

Like any interest in land, an easement may be condemned.

## 3.6 Restrictive Covenants:

Restrictive covenants are a very common part of most new subdivision schemes. Given the legal uncertainties and relative novelty of solar easements, the developer wishing to carry out the development scheme proposed by this report should add provisions in his covenants which further his goal of assuring unobstructed access to sunlight for buyers. One obvious provision which should be considered is the requirement that the primary dwelling unit for each lot be located on the land protected from shade defined for each lot. Such a requirement is similar to setback requirements which are often found in restrictive covenants and should be considered for several reasons:

-----By imposing this requirement on all lot owners, the developer will give assurance to all buyers that a common development scheme will be followed.

-----Because houses are the most likely obstructions to sunlight on adjoining land, such a requirement will lessen the possibility that an easement owner will have to go to court to enforce his rights.

-----Because any and all landowners have the right to go to court to enforce a restrictive covenant, the expense of court action can be spread among all landowners rather than just one--the easement owner.

-----The requirement will help assure that future owners will acquire a residence suitable for using solar energy even if the previous owner decides to build a home using conventional energy sources.

Similar restrictions might also be placed on the height and placement of fences and the planting of vegetation.

### 3.6.1 Model Form for Declaration of Restrictive Covenants to Protect Solar Access:

WHEREAS, the undersigned---------, is a fee owner of the following described property;

WHEREAS, the purpose of these restrictions, conditions, and reservations is to guarantee that a certain portion of each lot receive unobstructed access to sunlight for heating, agricultural, and any other purpose deemed appropriate by the owner to ensure the use of the property for attractive residential purposes or agricultural use only, to prevent the impairment of the attractiveness thereof, and to maintain the aesthetics and unique character of the area;

WHEREAS, these restrictions conditions and reservations have been established in accordance with a building plan and uniform adopted scheme, which plan and related documents are on file with the county clerk of the County of ----------, State of----------, recorded in book-------, at page----;

NOW, THEREFORE, this Declaration of Restrictions and conditions shall run with the land and is made to apply to the following described property situate, lying and being in ----------County, Montana, and more particularly described as follows, to-wit:

(Legal description of the property)

All persons, associations or corporations who now or shall hereafter acquire any interest in and to the above described property shall take and hold the same and agree and covenant with the owners of said tracts in said (name of subdivision), and with their heirs, successors, and assigns, to conform to and observe the following covenants, restrictions and conditions as to the use thereof and as to the construction of single family dwellings and improvements thereon, thereby providing a uniform plan for the development of the said entire area above described.

## A. DURATION OF COVENANTS

These covenants, restrictions and conditions shall be perpetual.

## B. PERMITTED AND PROHIBITED USES

1. No structure shall be built except within the "protected area" of each lot, as delineated on attached Exhibit A (plat showin protected areas).

2. No structure or vegetation of any kind will be allowed to reach such a height that causes them to shade any portion of any "protected area" of any lot, as delineated on attached Exhibit A.

3. These covenants may be enforced in law or equity by any party hereto or by any person or persons subsequently deriving title to the real property described in this declaration, or any portion thereof, from or through any party hereto or any successor in interest thereof.

That the said present owners, their heirs, administrators and assigns, and every person hereinafter having any right, title or interest in the aforedescribed land shall have the right to prevent or stop violation of any of these said restrictions, by injunction or other lawful procedure, and to recover any damages resulting from such violation, or from the enforcement of these restrictions, including reasonable attorney fees should resort be had to the Court for the enforcement hereof; the failure by these present owners, their heirs, administrators, or assigns, or by any person having any right, title or interest in and to the aforedescribed land, to enforce any restriction, condition, covenant, or agreement herein contained shall in no event be deemed a waiver of the right to do so thereafter as to the same breach or as to one occurring prior or subsequent thereto.

DATED at----------Montana, this-----day of--------, 19--.

By:----------
Owner

STATE OF----------)
) ss.
County of----------)

On this------day of----------, 19--, before me personally

appeared----------, known to me to be the persons whose names are subscribed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

Witness my hand and official seal.

---

NOTARY PUBLIC

My Commission Expires:

---

(Adapted from a form drafted by David L. Jackson, Esq., Helena, Montana)

# APPENDIX A.

# EXAMPLE SUBDIVISION PLAT

AUTHORS' BACKGROUND

EILEEN SHORE

Date of Birth: May 22, 1947
Place of Birth: Miles, City MT

Address: 1202 No. Lamborn
Helena, MT 59601

Phone: (406) 443-7446 (home)
(406) 449-3007 (work)

Professional Status: Member of the Montana Bar

Education:

Undergraduate: College of William and Mary, Williamsburg, VA, September, 1965 - January, 1967

University of Montana, Missoula, MT, September, 1967 - June, 1969. B.A. with Honors. Major: Political Science

Law: George Washington University, National Law Center, Washington, D. C.; September, 1973 - December, 1976, J.D. with Honors

Employment:

July, 1979 - Present: Chief Counsel, Montana Public Service Commission

June, 1978 - July, 1979: Staff Attorney, Montana Public Service Commission

December, 1976 - June, 1978

June, 1976 - August, 1976: Staff Attorney, The Environmental Quality Council, Capitol Station, Helena, Montana. The Environmental Quality Council is a legislative agency created by the Montana Environmental Policy Act to oversee its implementation.
Responsibilities: Responsible for all legal aspects of the Council's work, which primarily involves natural resources law. During 1977-1978, concentrated on energy issues. During the 1977 legislative session was in charge of EQC's legislative unit, assisting the House Natural Resources Committee in its consideration of proposed energy legislation. Co-authored "Energy and the 45th Legislature", served as a member of the Montana Energy Office's Solar Planning Committee, prepared a report on th alternative energy surcharge and wrote the "Montana Impacts" and

methodology sections of the state's response to the Bonneville Power Administraton's Role Environmental Impact Statement.

September, 1976 - December, 1976
September, 1975 - June, 1976
Pending Litigation Coordinator, The Environmental Law Reporter, 1346 Connecticut Ave., NW., Washington, D. C. The Reporter is a monthly publication which contains major judicial decisions, reports on current environmental issues, and summaries of legal papers filed in pending lawsuits.
Responsibilities: Reorganized the pending litigation service, collected legal papers in pending cases and summarized them for each issue, and traced the progress of pending environmental litigaton.

February, 1975 - July, 1975
Northern Rockies Field Representative, The Trust for Public Land, Missoula, MT. Headquarters: 82 Second St., San Francisco, CA, 94105. TPL is a non-profit organization which specializes in the acquisition of land for parks.
Responsibilities: Introduced the organization to the Northern Rockies area, initiated land acquisition projects and helped organize a citizen land trust in Idaho.

August, 1973 - December, 1974
Eastern Field Representative, The Trust for Public Land.
Responsibilities: Introduced the TPL to government agencies, citizen groups and private individuals in the Northeast United States. Worked as a liaison with executive agencies of the federal government, traced the progres of selected legislation in Congress, and initiated land acquisition projects.

May, 1971 - August, 1973
Director of Administration, The Nature Conservancy, 1800 North Kent, Arlington, VA, 22209. The Conservancy is a non-profit organization which specializes in preservation of natural areas.
Responsibilities: Supervised a five person department and the department's budget and was responsible for all personnel and administrative functions of the organization's national office and four regional offices.

THOMAS STEWART

Date of Birth: February 15, 1936
Place of Birth: Warren, Ohio

Address: 8945 Douglas Circle
Helena, MT 59601

Phone: (406) 458-9729

Professional Areas of Ability and Experience:

General Civil Engineering Areas
Structural Engineering Analysis and Design
Computer Applications (Technical and Non-technical)
Applied Mathematics
Teaching in areas of Computer Science, Applied Mathematics, Engineering Mechanics, Numerical Analysis, Engineering Graphics, Linear and Non-linear Programming
Currently researching all technical aspects of solar energy use for the heating of buildings

Educational Background:

B.S., Civil Engineering, University of WA, 1962
M.S., Civil Engineering, Montana State U., 1963
Master's thesis on Alkali-aggregate reactions in concrete research program in concrete technology.

1972 - On leave from Carroll College. National Science Foundation Grant under a program for the improvement of college teaching in science at Montana State U. This work was accredited toward a doctorate program in Civil Engineerng.

1976 - Sabbatical leave from Carroll College to finish course work for doctorate in Civil Engineering, Montana State U. Graduate courses in Operation Research Mathematics and literature search of Solar Energy technology.

Certification: Professional Engineer, Registration No. 2220E, Montana State

Employment:

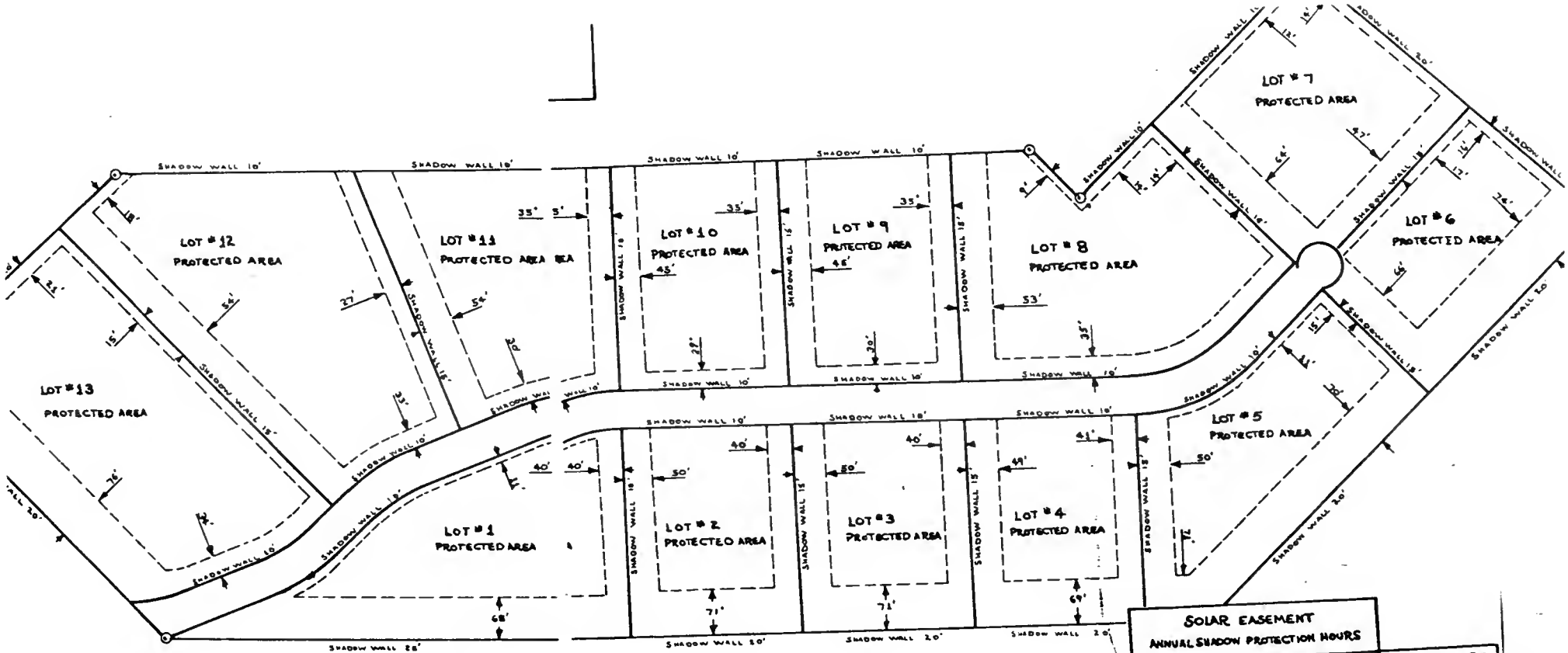
May, 1978 - present:
Independent consultant. Three-fourths of my time is presently spent under contract to develop computer models for air pollution studies. Contract is with the Montana State Air Quality Bureau and expires on July 1, 1980. One-fourth time is spent in developing software applications for micro-processors.

1978 - 1965:
Carroll College, Associate Professor in Engineering and Mathematics. Directed Engineering curriculum

program in affiliation with Columbia University, Notre Dame, U. of So. California, Montana State U., and Montana College of Mineral Science and Technology. Teaching in areas of engineerng, mathematics, and computer science.

1965 - 1963:
Montana State Highway Commission. Bridge design work and development of computer applications to bridge design and earthwork design.

Prior to 1963:
Miscellaneous jobs during college years with Boeing Aircraft in Metallurgy Lab as research assistant, Grant County PUD, Columbia River Hydroelectric Project, City Engineering, Washington State Highway Survey work.




# SOLAR EASEMENT
## Overlay of
## SOLAR HEIGHTS SUBDIVISION

LOCATION: S.W. ¼ of SECTION 1
TOWNSHIP 10 RANGE 4 WEST M.P.M
LEWIS and CLARK COUNTY
OWNERS: MITCHELL LOVELY and THOMAS STEWART
SCALE: 1 inch = 100 feet
DATE PREPARED: FEB 5 1980
DRAWN By: T.S.L

NOTE: Values in table are for the 21 st day of each month for a latitude of 46 58 degrees and a longitude of 112 03 degrees.

Clock times are approximate and do not account for day light Savings.

**SOLAR EASEMENT**
**ANNUAL SHADOW PROTECTION HOURS**

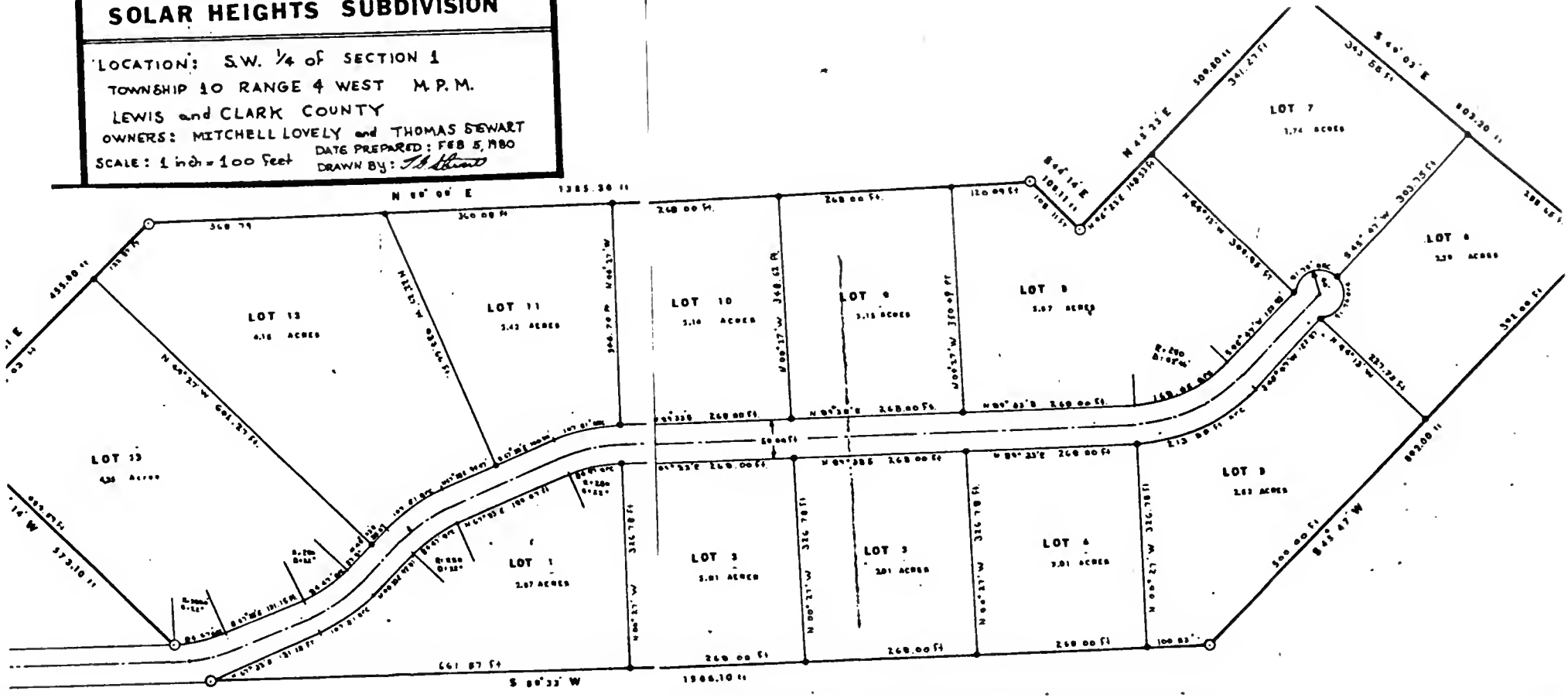
| MONTH | HOURS BEFORE AND AFTER SOLAR NOON | CLOCK TIME FOR SOLAR NOON (MOUNTAIN STD. TIME) |
|---|---|---|
| JANUARY | 2 ½ | 12:39 |
| FEBRUARY | 3 ½ | 12:48 |
| MARCH | 4 | 12:36 |
| APRIL | 4 | 12:28 |
| MAY | 4 | 12:25 |
| JUNE | 4 | 12:30 |
| JULY | 4 | 12:35 |
| AUGUST | 4 | 12:39 |
| SEPTEMBER | 4 | 12:41 |
| OCTOBER | 3 ½ | 12:13 |
| NOVEMBER | 2 ½ | 12:14 |
| DECEMBER | 2 | 12:27 |

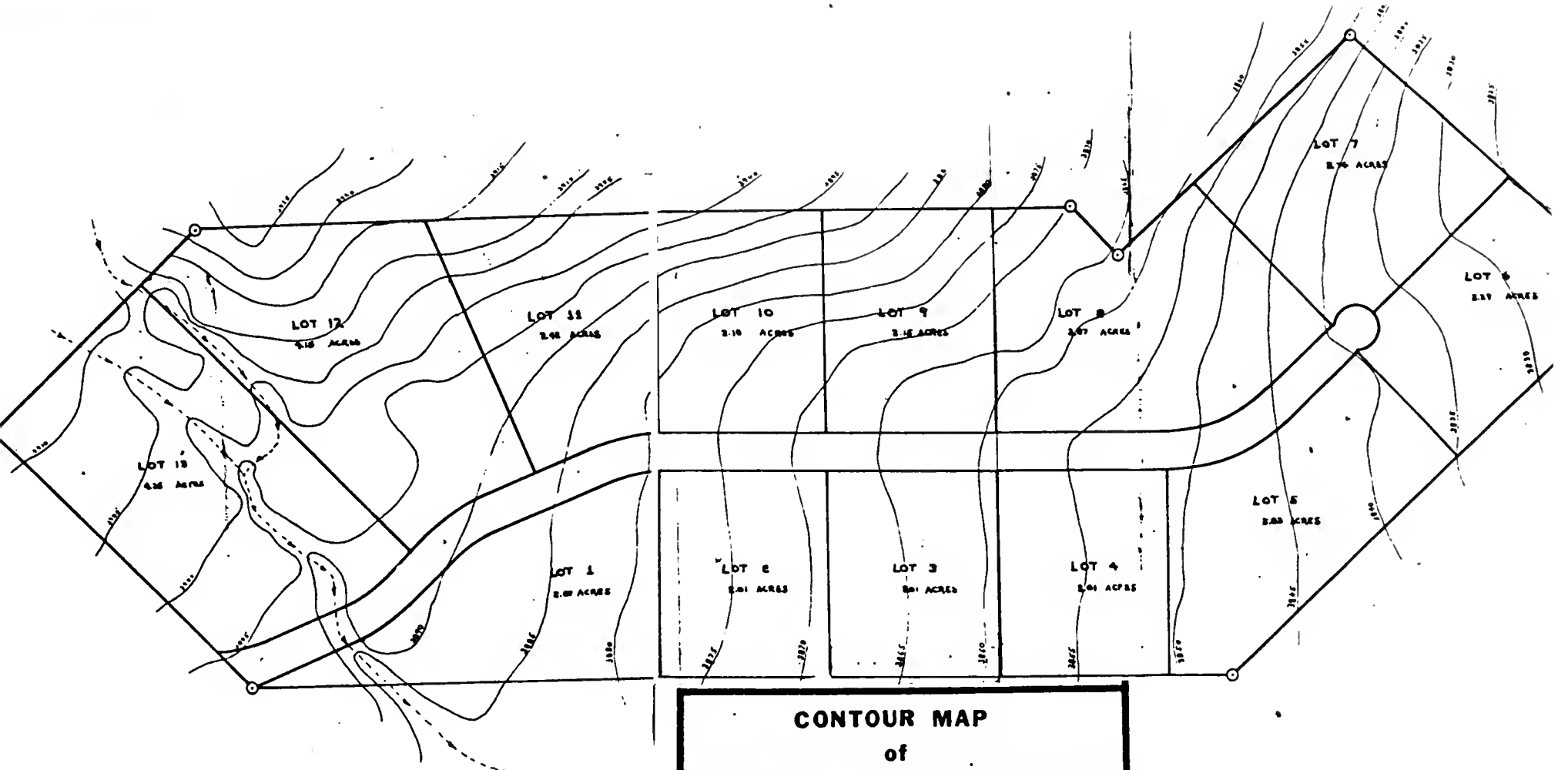
# APPENDIX C.

# CONTOUR MAP OF EXAMPLE SUBDIVISION

# PRELIMINARY PLAT
# of
# SOLAR HEIGHTS SUBDIVISION

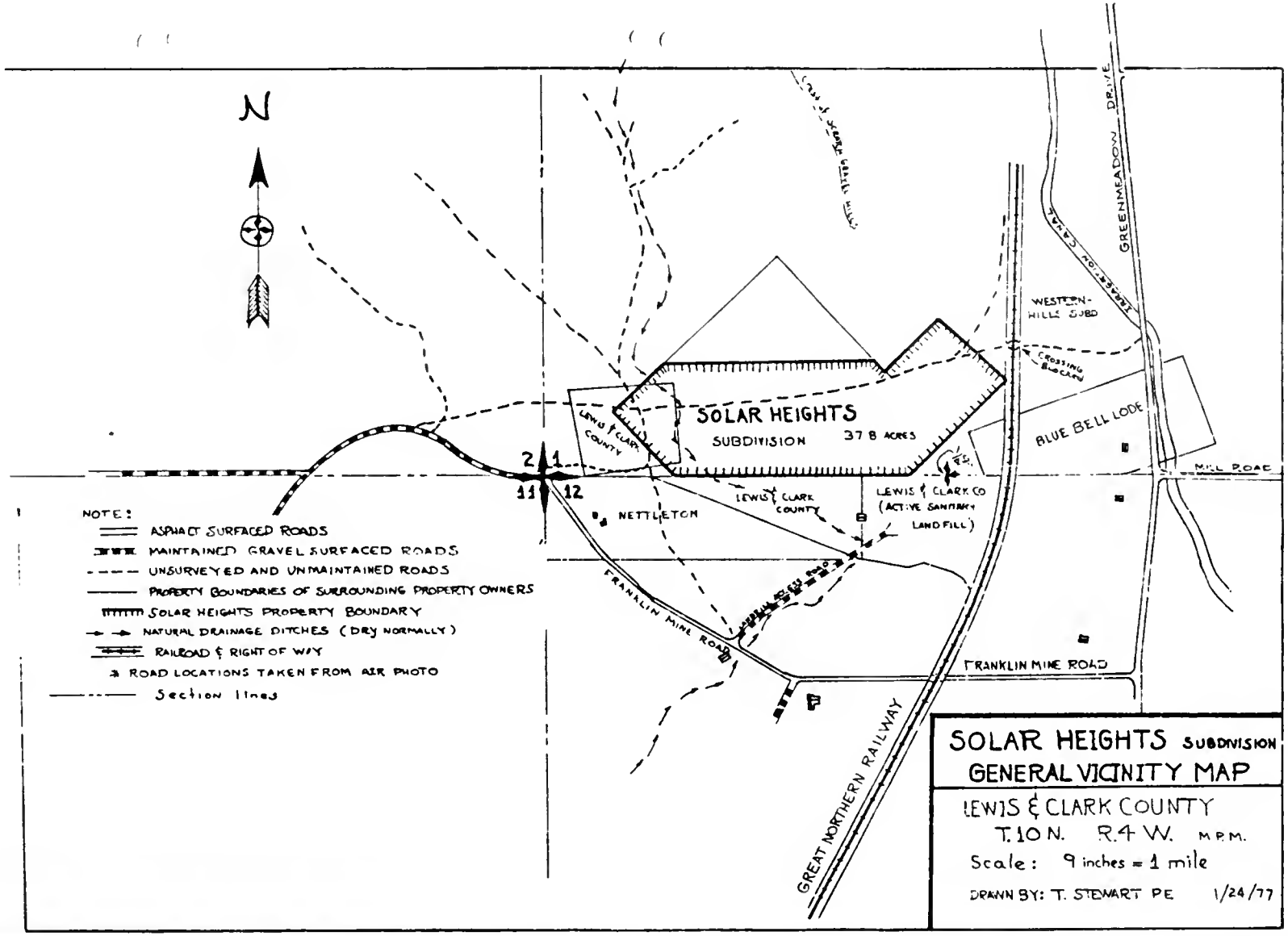
LOCATION: S.W. 1/4 of SECTION 1
TOWNSHIP 10 RANGE 4 WEST M.P.M.
LEWIS and CLARK COUNTY
OWNERS: MITCHELL LOVELY and THOMAS STEWART
SCALE: 1 inch = 100 Feet
DATE PREPARED: FEB 5, 1980
DRAWN BY: T.B. Stewart






# CONTOUR MAP
# of
# SOLAR HEIGHTS SUBDIVISION

LOCATION: SW ¼ of SECTION 1
TOWNSHIP 10 RANGE 4 WEST M.P.M.
LEWIS and CLARK COUNTY
OWNERS: MITCHELL LOVELY and THOMAS STEWART
SCALE: 1 inch = 100 feet
DATE PREPARED: FEB 5 1980
DRAWN BY TGS


N
SOLAR HEIGHTS
SUBDIVISION
37.8 ACRES
LEWIS & CLARK COUNTY
2
1
11
12
NETTLETON
LEWIS & CLARK COUNTY
LEWIS & CLARK CO
(ACTIVE SANITARY
LAND FILL)
FRANKLIN MINE ROAD
FRANKLIN MINE ROAD
GREENMEADOW DRIVE
WESTERN-
HILLS SUBD
BLUE BELL LODE
MILL ROAD
GREAT NORTHERN RAILWAY
NOTE:
ASPHALT SURFACED ROADS
MAINTAINED GRAVEL SURFACED ROADS
UNSURVEYED AND UNMAINTAINED ROADS
PROPERTY BOUNDARIES OF SURROUNDING PROPERTY OWNERS
SOLAR HEIGHTS PROPERTY BOUNDARY
NATURAL DRAINAGE DITCHES (DRY NORMALLY)
RAILROAD & RIGHT OF WAY
ROAD LOCATIONS TAKEN FROM AIR PHOTO
Section lines
SOLAR HEIGHTS SUBDIVISION
GENERAL VICINITY MAP
LEWIS & CLARK COUNTY
T. 10 N. R. 4 W. M.P.M.
Scale: 9 inches = 1 mile
DRAWN BY: T. STEWART PE 1/24/77

# BIBLIOGRAPHY


LEGAL LITERATURE ON SOLAR EASEMENTS:

Adams, AN ANALYSIS OF SOLAR LEGISLATION-TAXES AND EASEMENTS, XIV Land and Water Law Review 393 (1979).

Bersohn, SECURING SOLAR ENERGY RIGHTS:EASEMENTS: NUISANCE, OR ZONING?, Col. J. of Env. L. 112.

DESIGNS ON SUNSHINE: SOLAR ACCESS IN THE UNITED STATES AND JAPAN, 10 Coun. L. Rev. 123 (1977).

Eisenstadt and Utton, SOLAR RIGHTS AND THEIR EFFECT ON SOLAR HEATING AND COOLING, 16 Natural Resources Journal 363 (1976).

Hayes, SOLAR ACCESS LAW: PROTECTING ACCESS TO SUNLIGHT FOR SOLAR ENERGY SYSTEMS, Environmental Law Institute, 1346 Coun. Ave., N. W., Wash., D. C., 20036 (1979).

Kraemer, S., SOLAR LAW, PRESENT AND FUTURE WITH PROPOSED FORMS, (1978).

Maskowitz, LEGAL ACCESS TO LIGHT: THE SOLAR IMPERATIVE, IX Natural Resources Lawyer 177 (1976).

Miller, SOLAR ACCESS AND LAND USE: STATE OF THE LAW, 1977, Environmental Law Institute, 1346 Coun. Ave., N. W., Suite 620, Wash., D. C., 20036.

PROTECTING SOLAR ACCESS: PREVENTING A POTENTIAL PROBLEM, 7 Golden Gate U. L. Rev., 765 (1977).

Seeley, D., SOLAR ENERGY LEGAL BIBLIOGRAPHY - FINAL REPORT, Published by the Solar Energy Research Institute (1979).

SOLAR RIGHTS: GUARANTEEING A PLACE IN THE SUN, 57 Ore. L. Rev. 94 (1977).

Thomas, OVERCOMING LEGAL UNCERTAINTIES ABOUT USE OF SOLAR ENERGY SYSTEMS, American Bar Foundation (1978).

Thomas, SOLAR ENERGY AND THE LAW, 83 Case and Comment, No. 6, p. 3 (1978).

TECHNICAL REFERENCES:

HANDBOOK OF FUNDAMENTALS, HEATING, REFRIGERATING, VENTILATING AND AIR CONDITIONING, Published by American Society of Heating, Refrigerating and Air-Conditioning Engineers, (1976).

Duffie and Beckman, SOLAR ENERGY THERMAL PROCESSES, Solar Energy Laboratory, University of Wisconsin, Madison, A Wiley-Interscience Pub., (1974).

16 copies of this public document were published at an estimated cost of $6.00 per copy, for a total cost of $96.00, which includes $96.00 for printing and $.00 for distribution.